AIRCRAFT & MISSILES

A Chilton Publication APPLIED ENGINEERING FOR THE AEROSPACE INDUSTRIES July 1960

The "Not So Auxiliary" Power Systems . . . P 28

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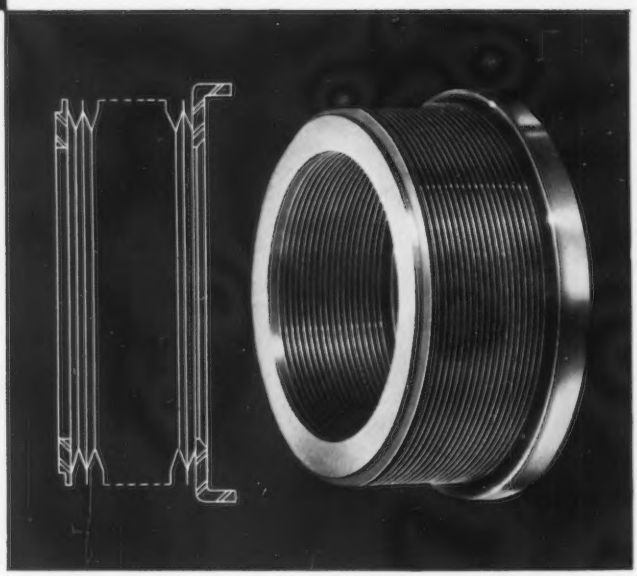
C/R DESIGN NOTES

How C/R's New Metal Bellows Seal Meets Seemingly Impossible Operating Conditions



Operating Ranges

Temperature	−400° to 1000° F.
Pressure	500 psi
R.P.M.	80,000 plus

These known operating ranges indicate the function of this seal. It is designed for applications where temperatures and mediums to be sealed forbid the use of any organic materials. Typically, these applications include fuel pumps, compressor power units and turbine starters characteristic in rockets and missiles. Other applications include mechanisms which are exposed to a high level of radioactivity.

Design Advantages

The C/R metal bellows seal consists of a metal bellows — a welded homogeneous unit which is secured at one end — and a carrier ring in which the sealing face is mounted. The seal does not contact the shaft. It is stationary, and the only rubbing surfaces are the sealing face and mating ring. These surfaces are precision lapped to provide a positive seal with minimum friction. At any given pressure, the seal can be designed to maintain proper and constantly effective face loads. It orients immediately to run-out and will resist any torques it is subjected to in operation. The design has high end-play tolerance: Chicago Rawhide engineers have deflected a bellows .100 in. for three million cycles at 1750 cpm and at a temperature of 500° F. with no adverse effects.

A further advantage is relatively light weight and compactness. The C/R metal bellows seal can be designed for minimum axial and radial space. Axially, complete seals can be produced within a ¼ in. cross-section. Radially, dimensions are comparable with conventional end face seals.

The C/R metal bellows seal can also be designed with an extremely low coefficient of expansion. The importance of this factor becomes apparent with the fact that in many applications the operating temperature may change hundreds of degrees in a very few seconds.

Mediums To Be Sealed

Virtually any known liquid or gas may be positively sealed with this design, depending upon duration or service life. From a practical viewpoint, the C/R metal bellows seal is the best design for the sealing of cryogenic and high-energy fuels such as LOX, hydrogen peroxide, fluorine and other missile and rocket propellants.

Where possible, lubrication of the two sealing faces is desirable to prolong service life. However, the medium being sealed commonly acts as the lubricant and may be merely hot gas.

Materials

Sealing faces and mating rings for the C/R metal bellows seal are available in a variety of materials including carbons, carbides, ceramics and various alloyed metals for both high temperature and corrosion resistance. The bellows can be furnished in any of several metals and alloys such as stainless steel, Monel, Inconel X, Ni-Span C and other special alloy steels.

Consult C/R Engineers

Each application for the C/R metal bellows seal is essentially a custom-design and an intimate knowledge of all conditions to be encountered must be known by Chicago Rawhide engineers to produce the correct combination of properties in the seal. Then, whether you require five, fifty or five thousand seals, Chicago Rawhide will design and produce the correct seal to solve your problem.

Helpful Design Data:

We will gladly furnish you with a design guide and space envelope data concerning the C/R Metal Bellows Seal. Just write for Bulletin MBS-1 on your company letterhead.

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In Canada: Chicago Rawhide Mfg. Co. of Canada, Ltd., Brantford, Ontario

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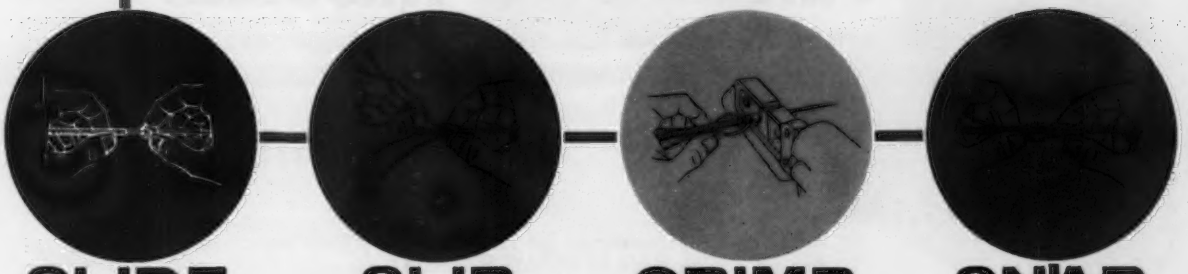
WHEN IT COMES TO SHIELDED WIRE



SLIDE on the ferrule

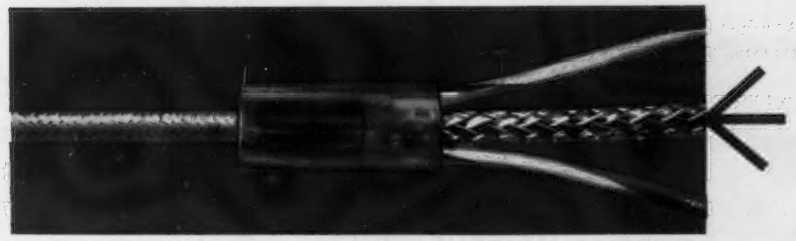
SLIP in the ground taps

CRIMP the three together

SNAP on the insulation

PRESTO!

the best insulated ferrule you can buy



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July, 1960 *Volume 3, Number 7*

AIRCRAFT & MISSILES

APPLIED ENGINEERING FOR THE AEROSPACE INDUSTRIES

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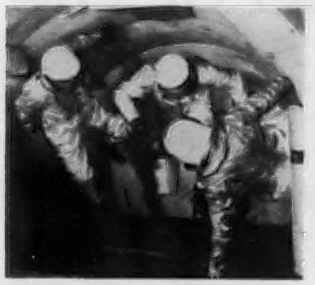
THE COVER STORY

The gravitational aspects of man's environment on Earth have been taken for granted since the dawn of his existence. Recent studies indicate that man can exist without the benefit of gravity. It remains to be seen however, just how long and how effectively. The homosapiens depicted on this month's cover are attempting to find the answers to these questions before they embark on Project Mercury. See Page 22.



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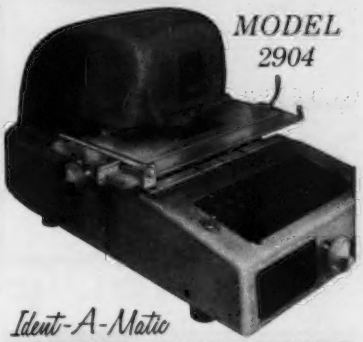

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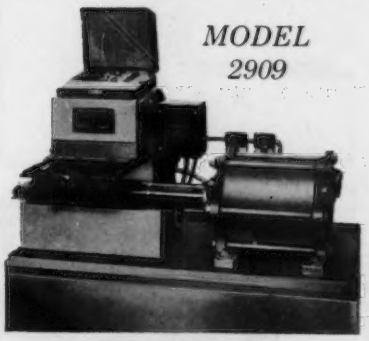

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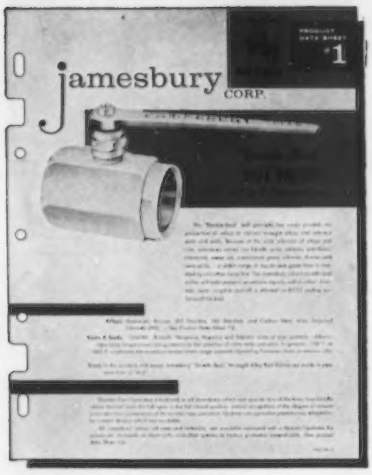

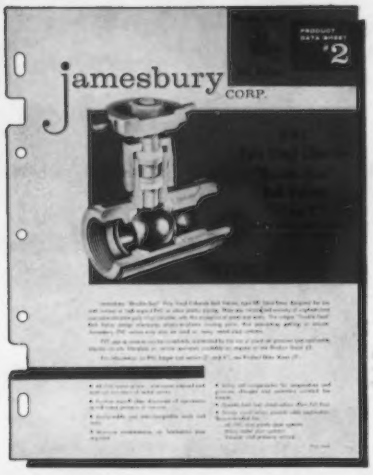

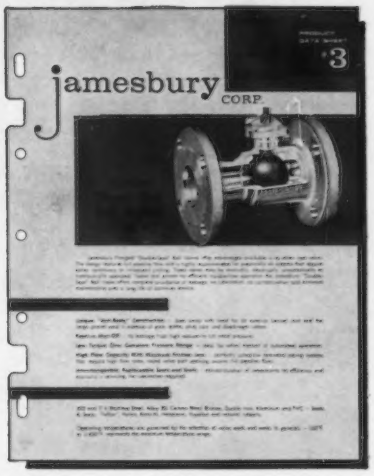

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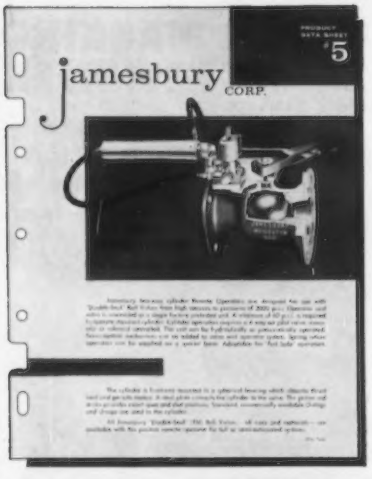

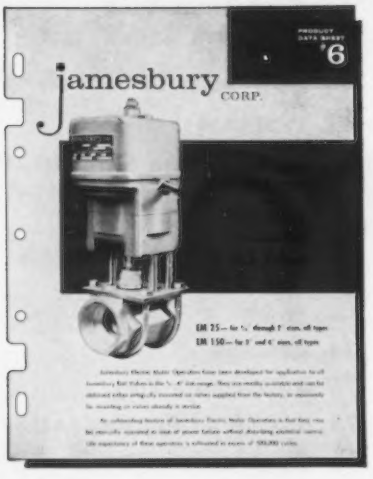

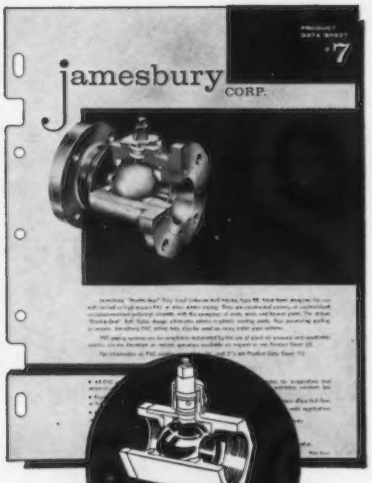

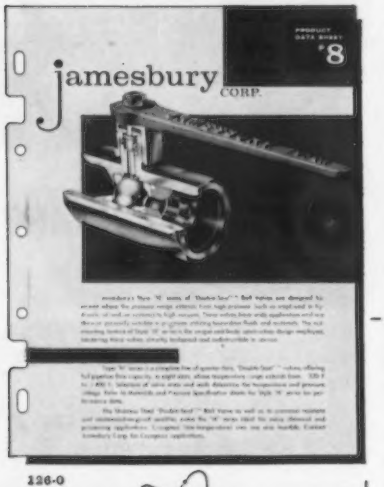

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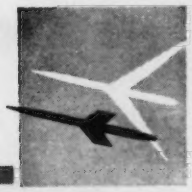

EDITORIAL

Do Our Security Regulations Need Updating?

Who needs to know what? Information restrictions are often applied to facts already properly known. This is what happens inside the Pentagon.

Recently, DOD released a document, "Fact Sheet, Guided Missiles and Rockets," number 344-60. Many items therein marked classified or "no releasable information."

Some of the unspeakables are well known in the aerospace industry. Yet, DOD still tries to suppress the facts.

Let's take a case. Most of you have heard of the Holy Moses or HVAR air-launched rocket. In the DOD handout, the no releasable tag is tacked on ceiling and range. Also, HVAR is called an air-to-air rocket. Actually, most were fired air-to-surface from 1944 during WW II until HVAR production was discontinued in 1955. Does DOD really mean that the ceiling and range are restricted? After all the weapon is obsolete.

Another item in the DOD document states no releasable information on length and diameter of Polaris. Pictures have been released for some time showing overall missile size. Who's kidding whom?

There are other items, but why go on. The point is simply this: do we need such useless, time-consuming security rules?

Industry and the public as well must know the state of our defense effort. Our engineers and scientists must know to design even better weapons. Still, DOD insists on hiding the facts.

Such needless rules have cost us time and money. Two firms working on different missle systems are seldom given data on each other's system. Even though public money is involved, DOD acts like it has proprietary rights. Thus, the two firms can go down the same path when actually they could complement each other. It happens too that they hit the same blind alleys of research.

How often do you seek the assistance of DOD in your work? More likely you turn to fellow engineers, magazines, or professional societies for information.

It's about time we did something about the situation. Our proposal is this: Set up security review boards consisting of engineers or scientists from industry, businessmen and elected representatives to government. Such boards should have advisors from the military, intelligence, and State departments. A time cycle should be established for review of all material.

Let's have no Civil War cannon buried in the archives of security.

Tom MacNew

Editor

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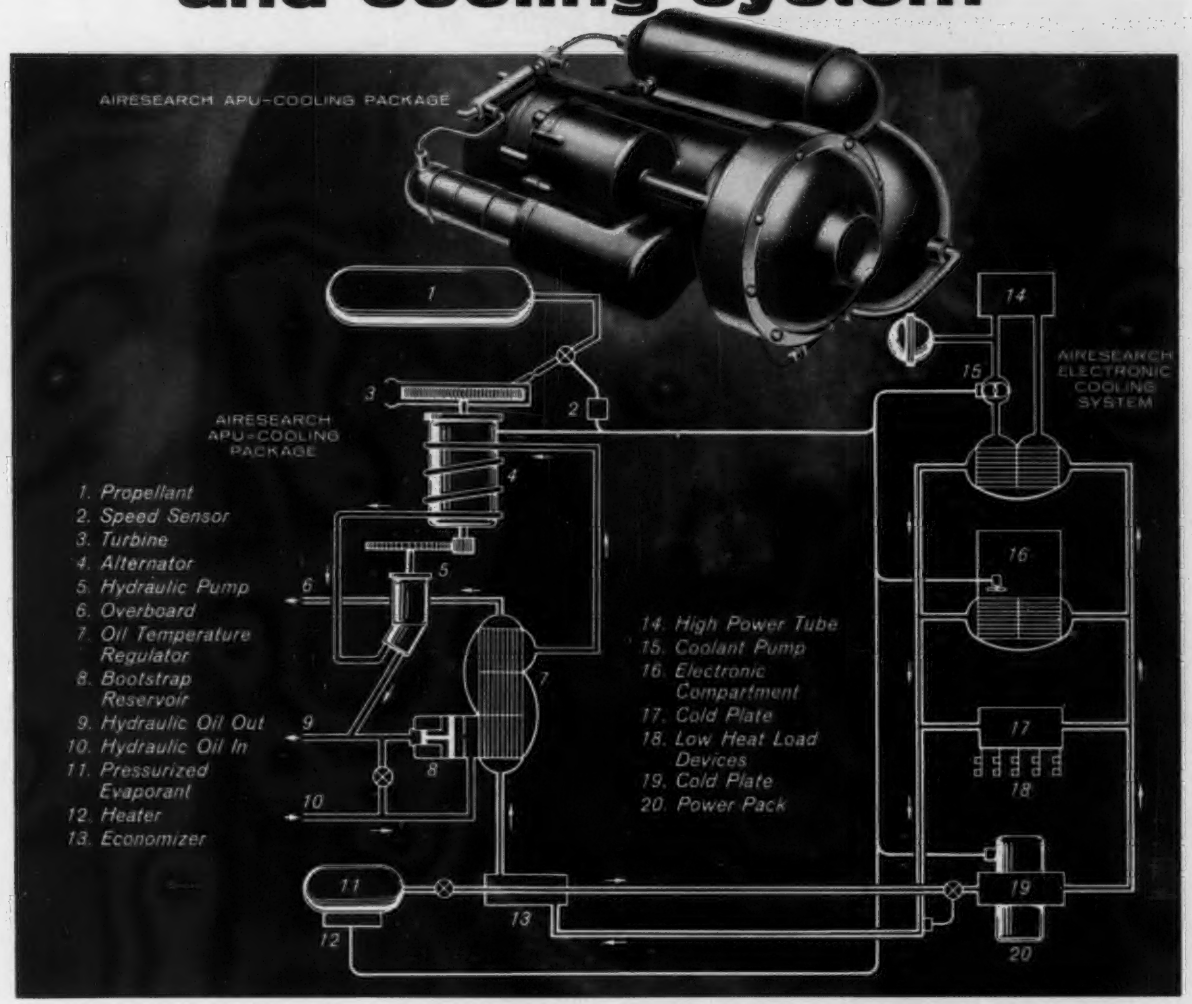

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The cooling system in the example shown here uses liquid ammonia as the expendable evaporant, and each heat load area has a separate temperature control valve. Alternator and controls, turbine assembly and APU liquid propellant fuel tank are patterned after operationally proven components.

World leader in the design and manufacture of cooling and accessory power systems, AiResearch has delivered more missile APUs than any other company, and is the leader in advanced electronic cooling systems for aircraft, missiles and spacecraft.

AiResearch design and manufacturing experience in these two fields includes: liquid and solid propellant APUs; hydraulic and hot gas actuators and control systems; 3200 and 400 cycle alternators; cold plates; expendable and closed cycle gas and liquid cooling systems; cryogenic cooling systems.

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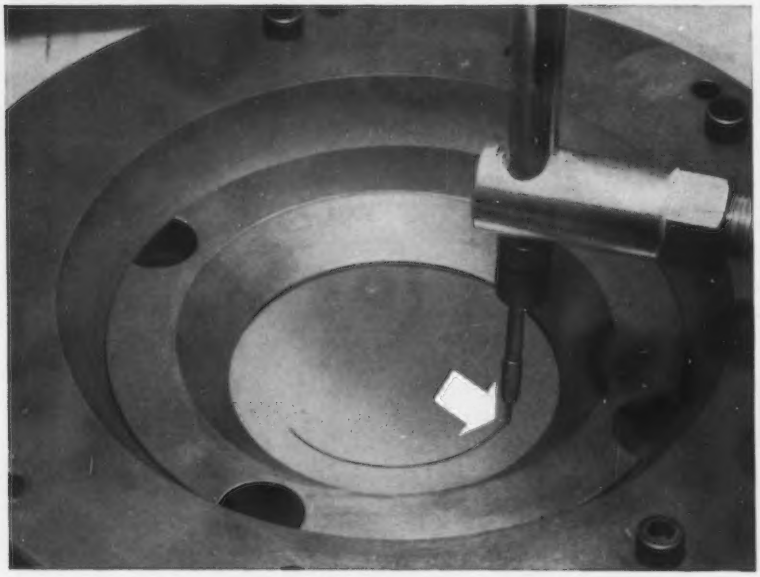

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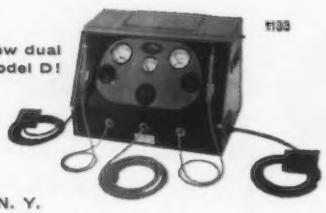

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Reader's Orbit

Timely and Exact

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Best Mercury Article

. . . We are actively engaged in the telemetry and instrumentation of Project Mercury. Your article in the April issue of A&M was very timely. It answers a lot of questions we have from the other half of the team. . . . I believe this is the most informative article any of us have seen. We normally would not get this information . . . (getting it) helps in the design of the ground based equipment.

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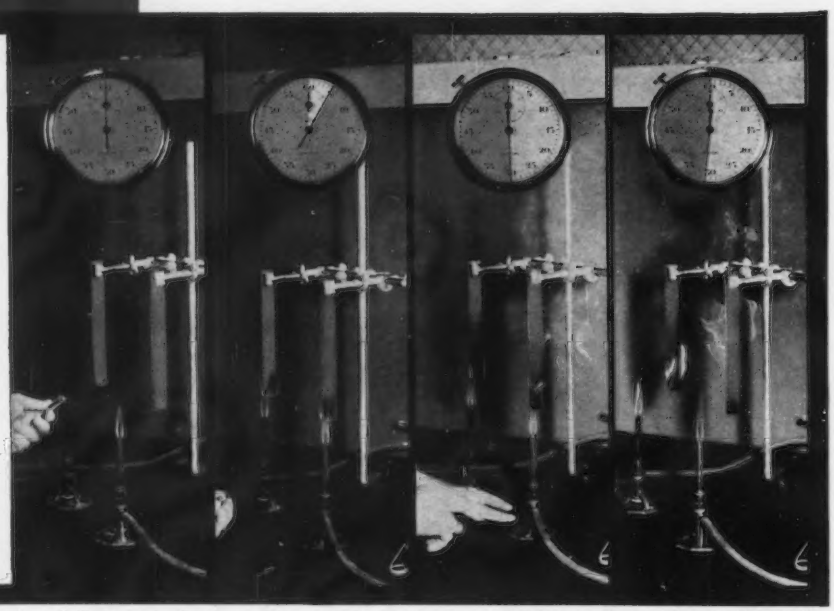
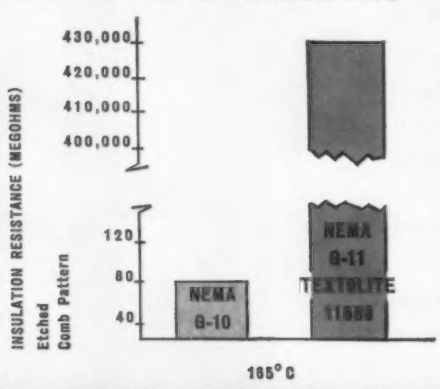


Actual flame test of a non self-extinguishing glass-epoxy laminate and Textolite G-11 (11559) glass-epoxy laminate. Less than two seconds after removal of burners, flame on 11559 dies, the other glass-epoxy laminate continues to burn.



Reduce fire hazard. This problem confronts many designers of computer and military electronic systems, especially where banks of circuit boards are required. Their solution . . . specification of G-11, self-extinguishing G-E TEXTOLITE 11559 glass-epoxy for printed circuits and structural electrical insulating material. Laboratory tests more severe than Standard ASTM flame tests prove Textolite 11559 flames-out within two seconds —never presents a fire hazard.

Easily exceeding requirements for NEMA G-11 laminates and specifications MIL-P-18177 Type GEB, transparent 11559 is available unclad or clad with 1 or 2 oz. copper on one or both sides. It surpasses other G-10 and G-11 laminates in its electrical properties at higher temperature ranges. Specifically, it provides low power factor, low dielectric constant and high insulation resistance into the 150° C range. Since it is highly resistant to solvents and etching solutions, rejects are considerably reduced.

For more information on 11559, consult Sweet's Product Design File, Cat 2b/Gen., or write: Laminated Products Department, Section AM-70, General Electric Company, Coshocton, Ohio.

Progress Is Our Most Important Product

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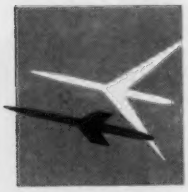
Data Capsule



SUMMARY OF MANAGEMENT TRENDS AND TECHNICAL DEVELOPMENTS IN THE AEROSPACE INDUSTRIES

MISSILES AND SPACE VEHICLES

Design

ZERO "G" liquid oxygen converters are being designed at AiResearch for the Air Force. Use: breathing systems for space travelers.

MAULER new version could be fired "on the run" against missiles and aircraft. Seagoing version with anti-sub capabilities being considered.

Development

F-1 TURBOPUMP ready for test at Rocketdyne. It will feed fuel to 1,500,000-lb.-thrust engine at rate of three tons per minute.

NEW ION ENGINE being developed at Hughes Aircraft for NASA.

SAMOS-MIDAS COMPLEX at Point Arguello ready for use.

MINUTEMAN MILESTONE: its second stage engines have undergone full duration firings at Aerojet General.

THIOKOL NUCLEAR WORK now centers in nuclear propulsion unit at Parsippanny-Troy Hills, N. J.

100 R & D PROJECTS of the future will be covered in a book to be issued this Fall by the Office of Technical Plans, Army Signal Research and Development Labs. Projects cover advanced equipment the Signal Corps will require to overcome Russian capabilities. Portions classified secret.

TS-609A high altitude rocket will be Air Force version of NASA's Scout. Aeronutronics, system engineer and payload and test contractor, will assemble it from existing solid propellant rockets. Chance Vought will build the first three stages. Missions include missile re-entry studies, launching large-scale models of space vehicles such as Dyna-Soar, and launching R & D payloads.

NUCLEAR ROCKET STUDY CONTRACTS being awarded by NASA. Step towards orbital flight test atop Saturn in 1965.

FULL TRANSFER EFFECTED: ABMA's Development Operations Div. fully absorbed in NASA July 1. Now called the George C. Marshall Space Flight Center with launch vehicle development and operations responsibility.

GODDARD SPACE FLIGHT CENTER at Greenbelt, Md. opens next month for NASA payload development.

Production

BOMARC BACK? Senate favors restoring $294-million which the House had cut from Bomarc B production.

SKYBOLT & HOUND DOG automatic ground check-out system will be produced by Bendix Aviation's Support Equipment Section, Teterboro, N. J. Designated AN/GJQ-9, it checks electronic, pneumatic, and hydraulic systems.

NEW PACKAGING SYSTEM at Rocketdyne cited for 89 per cent reduction in cost of parts damaged.

HUFFORD SPIN FORGE, weighing almost 600,000 pounds, slated for completion next month. The 120-inch machine tool will form missile and space vehicle components up to 10 ft. in diameter and 24 ft. long. Siegler Corp. invested $1,250,000 in machine and special building to house it.

Procurement

CONGRESSIONAL BOOSTS expected in funds for Bomarc, Davy Crockett, Samos.

LARGE CONTRACT may stem from studies on the Field Army Ballistic Missile Defense System. Army has solicited proposals, will reportedly award several contracts for feasibility studies, followed by a large R & D contract.

AIRCRAFT

Design

F-86 SABREJET can now reach supersonic speeds. Ceiling is over 60,000 ft. Variable thrust AR2-3 rocket engine, slung beneath the fuselage, gives augmentation power. Jets in pods are also being considered to augment speed, lift, and range of helicopters.

AIRSHIPS proposed by Goodyear Aircraft could carry boosters 25 ft. in diam., 80 ft. long and up to 30,000 lb. Goodyear would modify its current ZPG-3W to reach envelope capacity of 1,500,000 cu. ft.

BOEING 720 has new wing shape for increased cruise speed. Wing is angled more sharply to the fuselage at the inboard section than on the larger, slower 707-120's and Intercontinentals. It is also thinned for increased speed and lift. Leading edge flaps are extended almost the full wingspan.

Development

NEW AFT FAN, described as a "fan burner," could power supersonic transports, according to J. B. Montgomery, general manager of General Electric's Flight Propulsion Div. Engine would burn fuel in the exhaust of a fan mounted directly behind the basic jet engine.

EMERGENCY OXYGEN SYSTEM for jetliners has been developed by Robertshaw-Fulton Controls Co. It weighs 1½ lb.

B-70 may regain its position as a top development program. Senate Defense Appropriations Subcommittee added $285-million to the $75-million approved by the House for the program.

F-106 FIGHTER a bone of contention in Congress with cutbacks possible. F-106 was to have been developed as substitute for Bomarc.

OBSERVATION HELICOPTER design under close study. New craft will be developed to replace Cessna L-19, Bell H-13, and Hiller H-23. Navy has charge of design studies and will invite bids on development by about January.

DYNA-SOAR GLIDE TESTS at high Mach slated for Fall of '63.

JET FUELING SYSTEM, being service tested at Tactical Air Command, is transportable complete in one plane. Handles 50,000 gallons in five fabric tanks manufactured by Goodyear Tire & Rubber. Bowser Inc. developed equipment.

TILTABLE TAILPIPE, designed to give Grumman A2F STOL capability, was recently actuated in the air. This increased rate-of-climb. Trim changes "minor."

Production

LOCKHEED AND KAISER are launching South American aircraft manufacturing venture. Called Aviones Lockheed-Kaiser Argentina, it is equal partnership of Industrias Kaiser Argentina and Lockheed Aircraft International. New factory will be built in Cordoba, 400 miles northwest of Buenos Aires.

HOVERCRAFT will be produced by Vickers in collaboration with Hovercraft Development Limited. Two prototypes will be manufactured: one about five tons and one between 15 and 25 tons.

PT6, 500 hp turboprop for executive aircraft types, has been running in test cells at Canadian Pratt & Whitney Aircraft. Engines will be available for flight test next year. Production engines are expected to be available in April of '62.

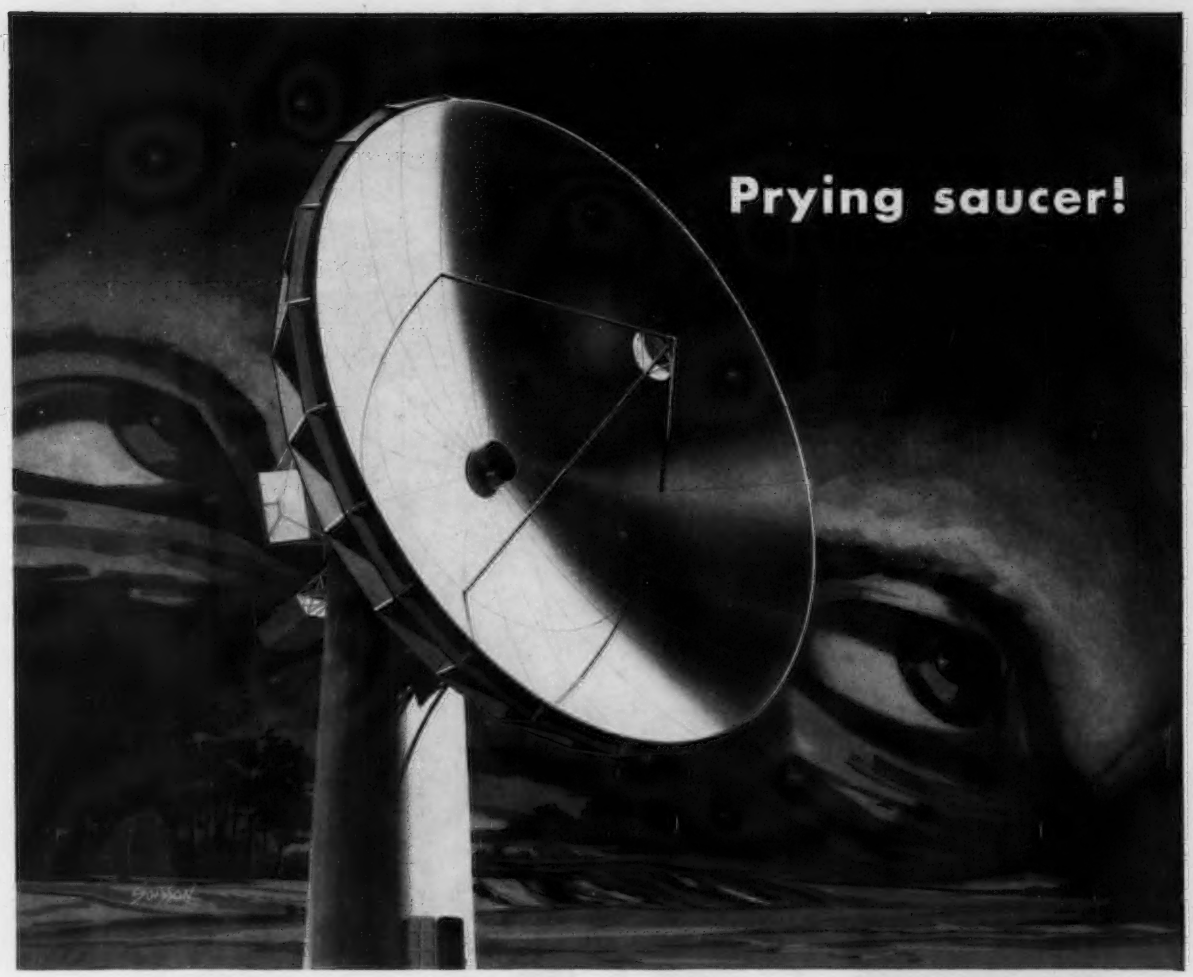
SECOND GRUMMAN A2F-1 in final assembly. To facilitate ground maintenance, 60 per cent of Intruder's fuselage surface is access doors. Big problem: building interchangeable doors.

FIRST ZPG-3W AIRSHIP, largest non-rigid ever built, delivered to Navy by Goodyear Aircraft.

PROJECT RUM, Remote Underwater Manipulator, under development at Scripps Institute of Oceanography, will aid underwater exploration. RUM will "swim" under ocean suspended from Hugnes Aircraft lift appendage fitted with prop-driven rotors.

Procurement

THREE MORE 880's ordered by Delta Air Lines.



IN DIAMETERS UP TO 300′, Aeronca antennas provide unparalleled accuracy at frequencies of X-Band and higher.

AERONCA designs and produces precision antenna systems for advanced radar complexes

Featuring new concepts in design and construction, Aeronca paraboloid antennas set new standards in precision . . . regardless of size. The principles and accuracy inherent in the 60-foot X-Band dish illustrated above are adaptable to antenna designs of virtually any size or shape.

Aeronca antennas are lightweight high-strength rigid structures of honeycomb sandwich construction. Developed by integrated design-tool-produce capabilities, they are fabricated by advanced techniques that substantially reduce tooling requirements . . . simplify unit design . . . assure low-cost producibility. In addition, Aeronca antennas permit lighter support structures and mechanisms because they weigh 40% to 60% less than conventional designs.

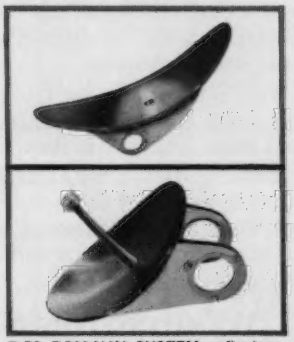
Whatever your antenna problems, Aeronca can supply "packaged" capabilities to meet your requirements and specifications. For details, write for BULLETIN AR-201.

AERONCA manufacturing corporation
1726 Germantown Road
Middletown, Ohio

Openings for creative R&D Engineers with Missile-Space experience. Write to O. E. Chandler, Mgr. Professional Employment.

8917-AC

APS-94 ANTENNA SYSTEM included complete design of antenna for airborne side-looking radar.



B-58 BOM-NAV SYSTEM reflectors feature curvature tolerances of ±.005″.

*Localized Steel Service Centers can fulfill your steel requirements and eliminate the necessity for inplant inventory, thus releasing your investment in raw material and increasing your working capital.

Don't take chances trying to outguess supply and demand. Adequate stocks are maintained in a wide range of types, shapes and sizes. Delivery is *immediate*.

MICROROLD STAINLESS STEEL is regularly carried in stock by many of these independent steel warehouses. Washington Steel is a producer of stainless sheet and strip exclusively, all of which is precision rolled on Sendzimir mills.

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Circle 13 on Inquiry Card

Your Datebook

June 28-July 1
National Summer Meeting
Institute of the Aeronautical Sciences
Ambassador Hotel, Los Angeles

July 5-15
Summer Program in Inertial Guidance
M.I.T., Cambridge, Mass.

July 11-12
Conference on Response of Metals to High Velocity Deformation
Metallurgical Society of the American Institute of Mining, Metallurgical, and Petroleum Engineers
Stanley Hotel, Estes Park, Colo.

July 18-19
Liquid Rockets and Propellants Conference
American Rocket Society
Ohio Union Bldg., Ohio State University, Columbus, O.

July 28-29
Seventh Annual Symposium on Computers and Data Processing
Denver Research Institute, University of Denver
Stanley Hotel, Estes Park, Colo.

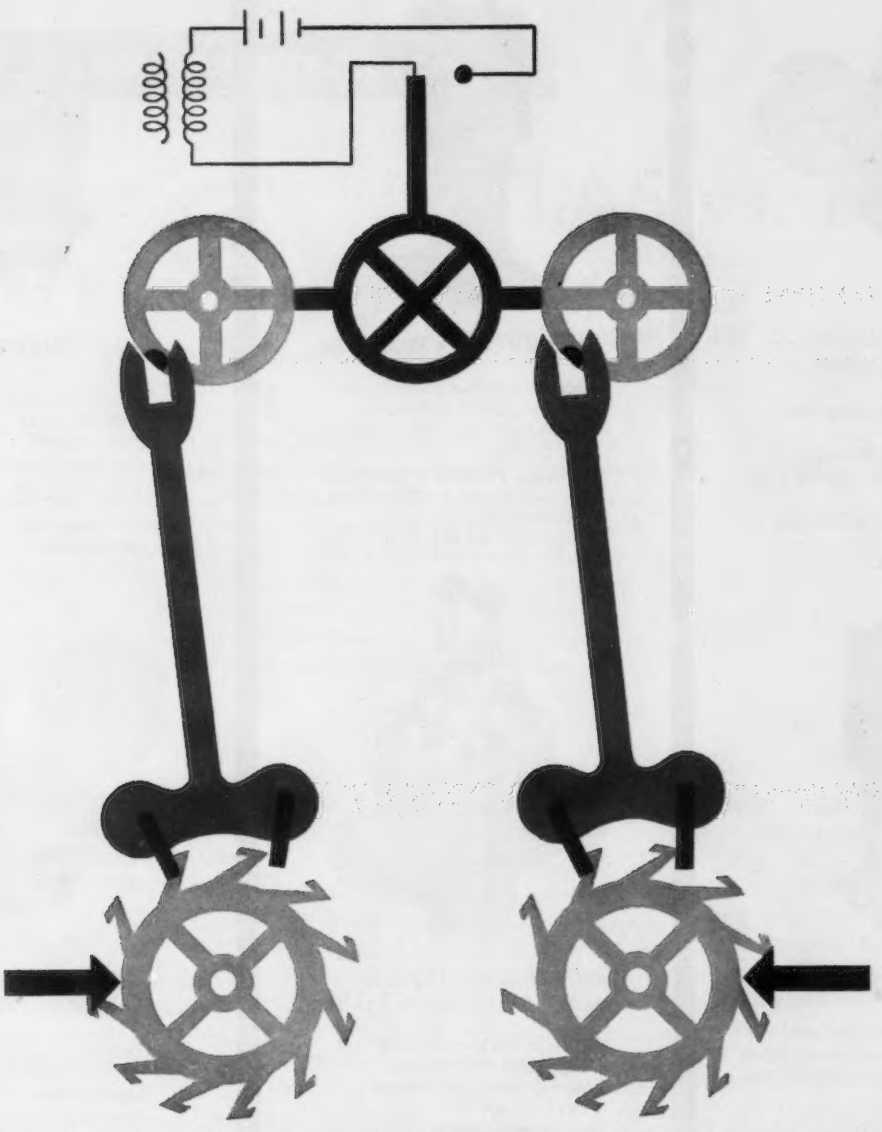
August 1-3
Fourth Global Communications Symposium
IRE, Army Signal Corps
Statler Hilton Hotel, Washington, D.C.

August 15-20
11th Annual Congress
International Astronautical Federation
Royal Institute of Technology, Stockholm

September 5-11
1960 Farnborough Display and Exhibition
Society of British Aircraft Constructors
Farnborough, England

September 6-16
The Machine Tool Exposition-1960
National Machine Tool Builders Asso.
International Amphitheatre, Chicago

September 27-30
Space Power Systems Conference
American Rocket Society
Miramar Hotel, Santa Monica, Calif.



Bulova dual channel balance wheel escapements

Bulova's talent for design, engineering and production of reliable timing devices has secured an important place for these critical mechanisms in our nation's industrial and defense communities.

The timing regulation of the sophisticated system shown above is based on the action of a simple balance wheel escapement. For every complete oscillation of the balance wheel, the levers permit scape wheel to advance one tooth according to the following.

In any given escapement, the principal variables which must be established are:
balance wheel frequency, f_b;
the gear reduction from scape wheel to mainspring, R;
and the torsional spring constant, Q, of the balance wheel hairspring.

The desired time per balance wheel cycle is determined by

$$(1) \qquad t = \frac{\beta n R}{2\pi f_b}$$

For optimum scape wheel functions over the range of mainspring torques, it is desirable to use the maximum balance wheel amplitude, just short of overbanking. Thus the balance wheel will have sufficient amplitude, Q, at lower mainspring torques.

The maximum energy imparted to the lever by the scape wheel must not exceed the energy absorbed by the balance hairspring. Therefore

$$(2) \qquad \tfrac{1}{2}Q(\triangle\emptyset)^2 \geqq \eta \frac{T_m\,(\triangle\theta)}{R}$$

where η is the efficiency of energy transmission from mainspring to hairspring, T_m, the maximum torque at hairspring, and θ, the angular displacement of the pallet. The factor, η, must generally be experimentally determined.

The third equation takes into account the fact that the balance wheel vibration system exhibits, by its nature, simple harmonic motion. Thus

$$(3) \qquad f_b = \frac{1}{2\pi}\sqrt{\frac{Q}{I}}$$

Where I is balance wheel inertia (constant for a given system).

The design procedure involves the choice of a convenient gear ratio and the definition of Q. Once Q is determined, f_b can be found by using Equ. (3). The R and f_b selected must be compatible with t.

Bulova's mastery of time and the high order of precision demanded in its regulation, materially contributes to our national well being.

BULOVA

Research & Development Laboratories, Inc.
62-10 Woodside Avenue, Woodside 77, N. Y.

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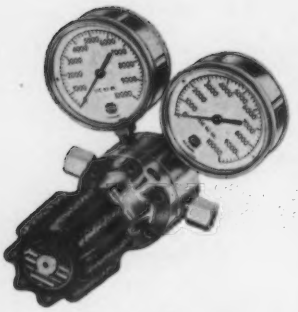


GD700 SERIES GAS-O-DOME REGULATORS

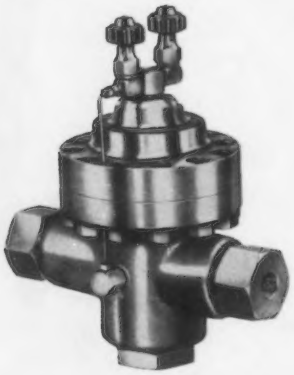
Models in bronze or stainless steel
Pilot operated type
Max. inlet: 7000 to 10,000 psig.
Outlet range: 10-150 to 400-7000 psig.
Flows to 250 scfm.
Low torque: 35 inch-lb. at 7000 psig.
Panel mounting
Bulletins R12 and R18.

BPR SERIES BACK PRESSURE REGULATORS

Models in bronze or stainless steel
Adjustable relief ranges: From 25-500 psig. to 2000-10,000 psig.
Panel mounting
Bulletin R19

LR SERIES LOADER REGULATORS

Models in bronze or stainless steel
Max. inlet: 7000 to 10,000 psig.
Outlet range: 5-200 to 200-10,000 psig.
Flow: 10 scfm.
Low torque: 35 inch-lb. at 7,000 psig.
60 inch-lb. at 10,000 psig.
Panel mounting
Bulletins R11 and R17



GD90, GD100A AND GD200A SERIES GAS-O-DOME REGULATORS

Models in bronze or stainless steel
Compensated, high-flow type
Max. inlet and outlet: 6000 psig.
Flows to 80,000 scfm.
Remote control and/or panel mounting provisions
Bulletin R18

LV-10 LOADER VALVE

Made in bronze only.
Inlet and outlet: 7000 psig.
Flow: 10 scfm.
Fast finger-tip control:
30° clockwise, loads;
30° counter-clockwise, bleeds.
Panel mounting
Bulletin LV-10

GD60 AND 80 SERIES GAS-O-DOME REGULATORS

Models in bronze
(stainless steel on request)
Inlet and outlet range: 2500 to 10,000 psig.
Flows to 1500 scfm.
Remote control and/or panel mounting provisions
Bulletin R10A

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Victor offers you choice of these and many other gas regulators for a wide variety of applications.

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ATLAS vs. TITAN

Are we paying twice to develop one ICBM capability?

Air Force has programmed for 13 Atlas squadrons and 14 Titan squadrons. Why? In all unclassified documents both missiles seem designed to the same mission requirements. Atlas, in some quarters, is called operational. It has demonstrated the capability of hitting a target 9000 mi away. Can Titan top this? What is more important, was it really ever intended to outperform Atlas? Has the cost of carrying a dual ICBM program to dual fruition ever been evaluated? Aircraft & Missiles West Coast Editor, Phil Geddes, reviewed the record and talked with unidentifiable but official sources in an attempt to clear the muddy waters. The results are extremely interesting.

Air Force is supporting several ICBM programs. Two are liquid fueled, big, and expensive. They are the Atlas and the Titan. A question being asked with repeated frequency is, "Why both?"

The basic design approach is different for both weapon systems. The performance limits of each are not so clearly different. So the next most logical question is, "Are we paying twice to develop one capability?"

In hearings before the Congress, Air Force gave this testimony in explanation to queries about the value of supporting both Atlas and Titan.

"Pros of Two Weapons—(1) Titan . . . has a maximum growth potential in both range and payload. This permits the continued use of operational bases for an effective, extended life.

"(2) Bringing both Atlas and Titan into the combat inventory would provide more tactical units in being during the near-term period, and by deploying these missiles the Air Force can attain a maximum ICBM inventory during the next few years.

"(3) . . . Atlas is achieving an effective reliability, but the promising Titan tests indicate a commensurate level of reliability. . . . Air Force cannot . . . risk the security of the country by untimely adoption of a single system until completion of research and development provides irrefutable evidence of superiority.

"(4) Retaining the Titan program enables the Air Force to make effective use of the significant investment already made (more than $1 billion) and retains, in the Air Force program, the element of competition and tactical flexibility.

"(5) Retaining the Titan program maintains an effective industrial base which will meet future demands of ICBM weapons systems, as well as programs having space applications.

"(6) . . . While the Atlas has growth potential, it must be accomplished through research and development and modification. However, the Titan in its present configuration, has inherent growth potential within the parameters of its present design.

"(7) The configuration of the Titan . . . will make it an excellent vehicle for space research and development and future operational systems. The increased payload capability and increased thrust possibilities, as well as the rigid skin construction, will all complement Titan as a space vehicle.

"(8) Cost savings to be gained in canceling the Titan program can only be viewed in the total perspective of the combined, complete programs, including operational force buildup. In this perspective, we are already approximately in the time period beyond which no total ICBM force cost savings can be realized by substitution of Atlas squadrons for Titan squadrons. The following factors are important in giving adequate assurance of meeting currently authorized operational force buildup schedules: (a) The total force acceleration potential including both Atlas and Titan is greater than for Atlas alone, particularly in the critical time period. (b) The dual industrial base provided by the combined Atlas and

Which has most potential for ICBM and space applications?

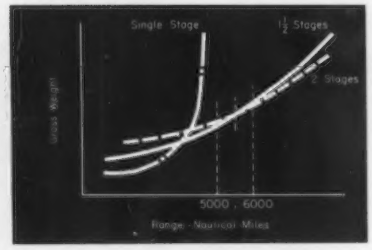


FIG. 1. PERFORMANCE PENALTY of multi-staging is apparent up to 5500 nautical mi. But, Atlas has higher gross weight giving payload edge shown in Fig. 2.

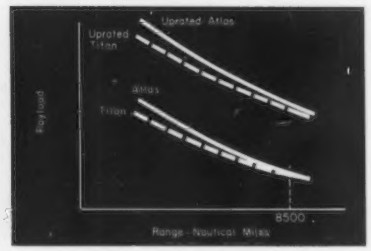


FIG. 2. OFFICIAL COMPARISON by government agency shows that Atlas has greater payload potential for 8000 to 9000 mi missions.

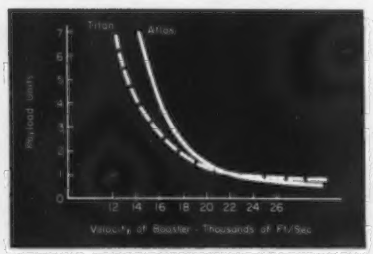


FIG. 3. SPACE BOOSTER comparison of Atlas and Titan gives Atlas an edge in attaining greater velocity with given payload up to 24,000 ft/sec.

Titan programs provides valuable confidence in meeting present schedules.

"Cons of Two Birds—(1) It is simpler to support one weapon system in the field, than it is to support two. Training, logistics, construction, etc., can all be concentrated if only one weapon system is utilized.

"(2) It would have been possible during the time period these two systems were under study to effect a savings of approximately $200 million over the entire period of the force buildup.

"(3) The Atlas has proven to be an effective platform for space missions and rather than waiting for the Titan as the next vehicle for space missions, the DOD might be able to wait for development of the 1½ million pounds thrust engine.

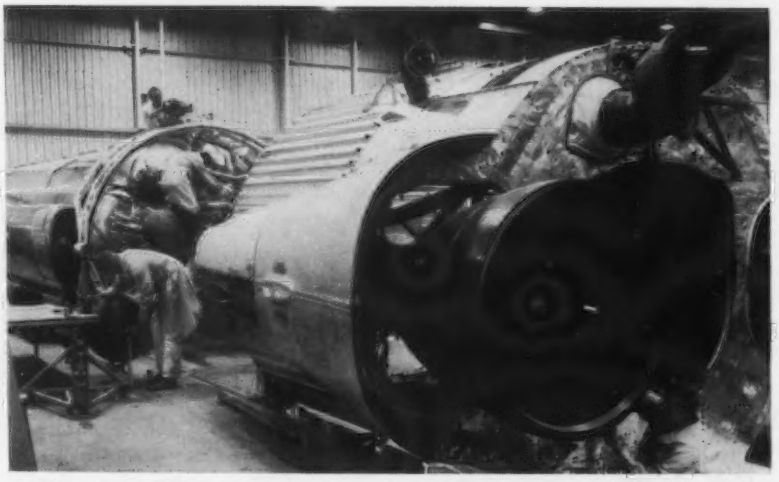
"(4) By modifications and continued research and development, the Atlas could attain the growth potential, greater payload carrying capability, and greater range. The Atlas has by now been proven reliable." [End of testimony.]

The Titan—This testimony certainly does not clear all the muddy water. But when it has been digested, it is not difficult to be of the opinion that Titan has greater potential than Atlas.

The attributes of Titan have also been echoed by authorities outside of the Air Force. Consider the following statement from Dr. Herbert F. York, Director Department of Defense Research and Engineering.

"A question that often arises in connection with the Atlas and Titan ICBM programs is 'why both?' The answer can be summed up by saying that Atlas is available now and provides ICBM strength at the earliest possible time. Titan on the other hand provides improved performance, increased sophistication and greater growth potential.

"It is more adaptable to the storable or noncryongenic fuels which should appreciably shorten its reaction time. It is also more adaptable to in-silo launch, which of course depends on having an all-inertial guidance system, among other things. It is a true two-stage missile, which should allow it to carry heavier warheads. Furthermore, its rigid structures make it better adaptable to adding heavy upper stages for space work."



ATLAS ENGINES are built by Rocketdyne. Design concept is basically the same. Two engines and structure drop off at stage separation. Atlas does not carry a "dead" engine.

This is a pretty strong case for Titan. Obsolescence seems to be rushing up on Atlas.

The Atlas—However, "The Atlas Team," as might be expected, has a much different opinion. They view the events leading up to the present Atlas vs. Titan hassle as follows:

Titan came into being as backup for Atlas. Reasons behind the decision to build a backup missile stemmed from distrust of the Atlas' pressurized monocoque structure. These doubts, however, were eliminated on the first flight. The guidance system malfunctioned and the missile pitched wildly while still full of propellant.

General Irvine later stated, ". . . it (Atlas) did some maneuvers that no solid structure—the Jupiter or Thor or any other system would stand."

Original payload requirement for present Atlas D and E models is identical to that of Titan I. Present Atlas and Titan carry essentially the same bomb size. In fact Atlas has already sported a Titan Mark IV nose cone. Both systems are capable of greater ranges than the design goal of 6,300 statute miles. An Atlas D travelled 9,000 mi May 20, 1960 and landed in impact area.

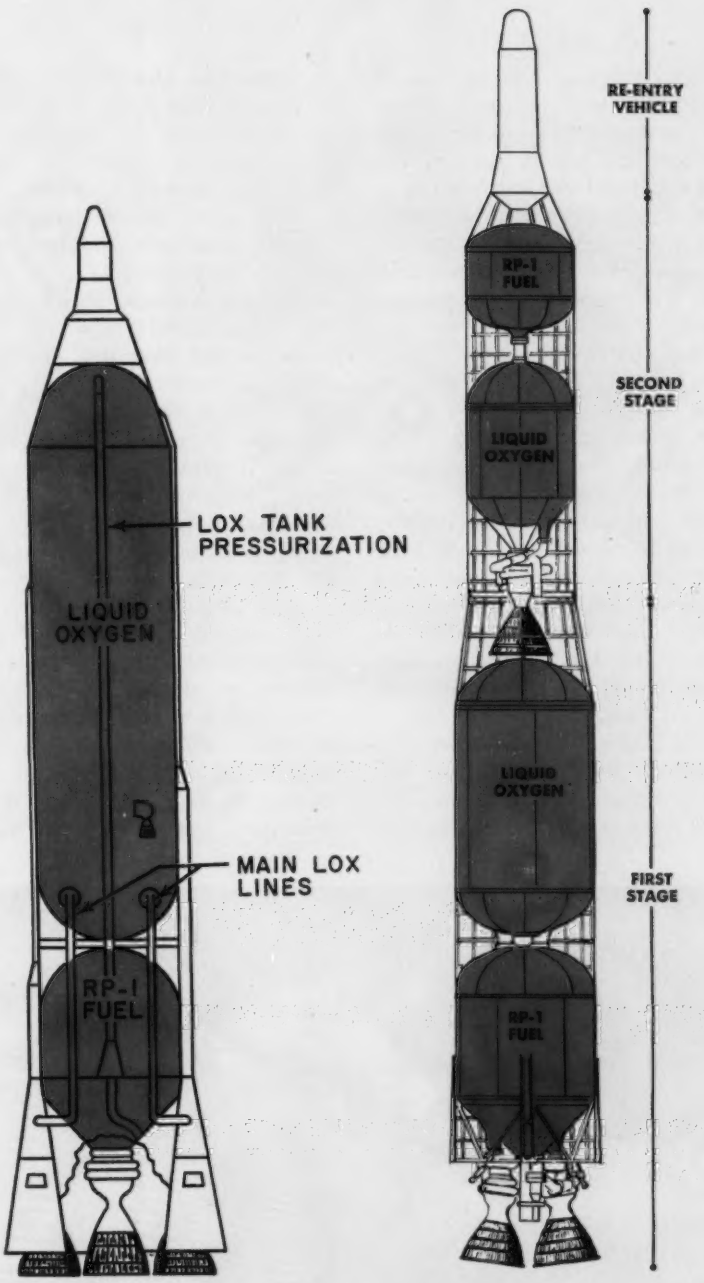
Atlas started with a radio inertial guidance system as is happening with Titan. By the time that the first Titan squadron with radio inertial guidance comes into operation, every Atlas will be fitted with all-inertial guidance. By the time Titan goes to all-inertial guidance, the Atlas system will be "product improved."

Staging Advantages—Atlas is called a "one and a half" stage missile. The "Atlas Team" sees this configuration with several advantages over the two stage Titan:

(1) All three motors started on ground.

(2) Simple staging technique. Force of the center stage separates the main booster from the sustainer at the required time. Everything you normally drop in a two stage

TWO BIRDS — ONE MISSION?



ATLAS DESIGN is called stage and one half. Airframe is of monocoque construction. Atlas figures heavily in current space programs. Will be used for Mercury.

TITAN DESIGN is a two stage affair. Airframe is of construction similar to that in aircraft. This is viewed by some as an advantage for boosting heavy payloads.

Are one and one half stages better than two?

configuration except tankage comes off at this time. No retro rockets are needed for stage separation. Performance penalty between one and a half and two stages is low as seen in classical comparison curve in Fig. 1. However, the Atlas has a higher gross weight (20 per cent) than Titan giving greater payload capability into the 9,000 mi area as shown in Fig. 2.

(3) Lighter in weight. Titan two stage design requires heavy structure around joint of stages. Tank structure is also heavier than Atlas. Air Force requested the reinforced design. In addition, a dead motor has to be carried to altitude from time of launch, and additional bulkheads are required in two stage design. There are three bulkheads in Atlas, eight in Titan. Two stage design means two sets of fuel and oxidizer lines.

(4) Lesser guidance and control problem. Two stages mean two sets of dynamic considerations since there are two missiles in one.

Atlas Can Use Storables—Use of storable fuels is one of the most important areas to consider in future growth. The Atlas team looked into desirability of new propellants against present propellants to make a decision. Non-cryogenic nitrogen tetraoxide (N_2O_4) as oxidizer, with hydrazine plus UDMH (N_2H_4 plus UDMH) as a fuel were evaluated then discarded. Nitrogen tetraoxide freezes at 12°F, hydrazine freezes at 40°F, thus both need temperature control in cold climates. It seems much cheaper and reliable to develop methods of storing liquid oxygen (RP-1 is already stored in the missile) than to use a new propellant combination. Cost of developing the new fuels could be considered in the hundreds of millions against cost in the tens of millions for developing cryogenic liquid oxygen storage. A factor of at least 15 difference between the development cost of the two for essentially the same application. The Atlas team decided in favor of storing liquid oxygen. With this approach, reaction time of Atlas system could be cut down to that approaching Minuteman. The basic configuration of the Atlas allows use of the same propellants as in Titan with no more problems than the use of such propellants would have in Titan.

In-Silo Firing—Atlas and Titan can both be fired from silos. Comparable versions of the two systems both use silo lifts to raise the missiles to ground level for firing. Scale model in-silo launches have demonstrated Atlas' ability to fire from bottom of silo. Titan in-silo launch is programmed for the 7th squadron.. Problems of in-silo firing are not concerned with structure but rather with electronic subsystems.

Space Boosters—Design studies on Atlas show that a 45,000 lb upper stage can be fitted without requiring any structural modifications. The Centaur-Atlas ordered by NASA is identical to the pressurized, monocoque Atlas ICBM. In Centaur, the second stage weighs approximately 30,000 lb. A stage the same size could be carried on Titan but here the 8-ft diam of the second stage would create some design problems. (Atlas is 10 ft in diameter.) In Fig. 3, comparing payload with velocity, note that at any given payload, a higher velocity can be obtained with Atlas until the point of intersection of the curve at slightly below 24,000 ft/sec. Large upper stages such as Centaur and Agena B will be boosted by Atlas or Titan up to velocities of 12,000 to 20,000 ft/sec.

NASA has scheduled 104 Atlases for use as boosters over the next ten years, reflecting confidence in the Atlas system. Titan is scheduled for use only as the booster in the Dynasoar project.

◆

TITAN ENGINES are built by Aerojet-General. Tapered stainless-steel tubes are welded and brazed over a mandrel. LOX is used for regenerative cooling.

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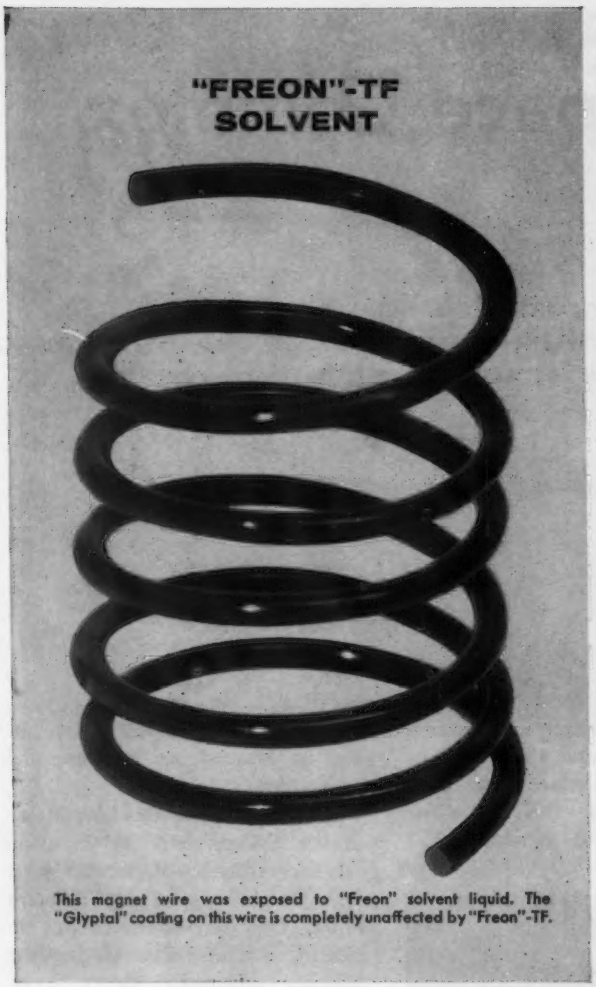
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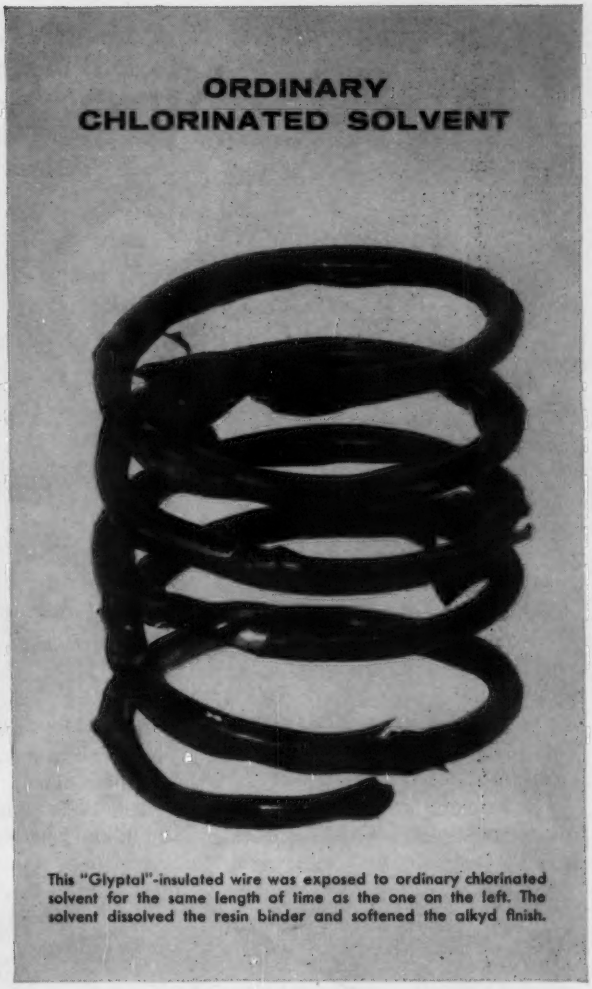
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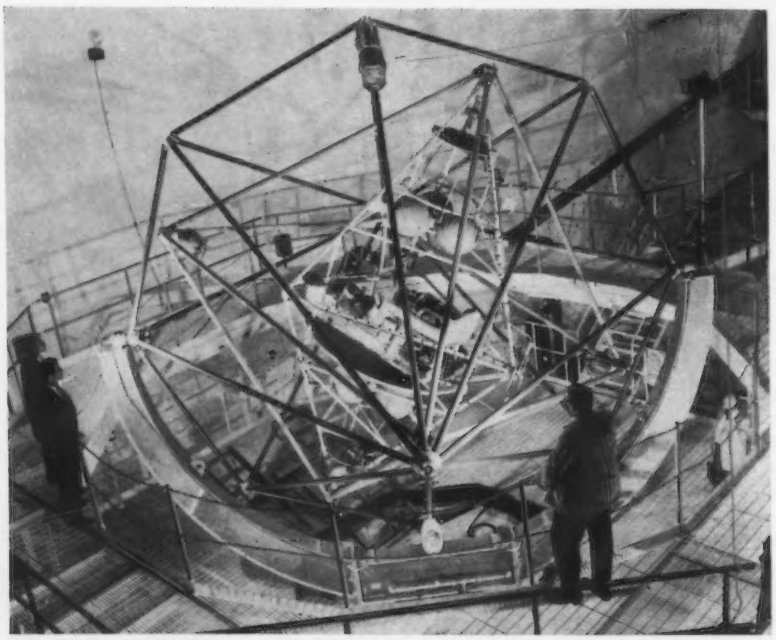
Man-Machine Space Complex

Putting humans in space demands studies of man's long-taken-for-granted earthbound needs; Effects of weightlessness pose biggest question mark, No device exists for earthbound tests at zero gravity

By Walter S. Wilson, Anthropologic Research, Chilton Co.

Manned space-flight is no longer an "if" question. The question now is "when." The answer is "soon," if all goes according to plan. Fruition is not more than a year or two away.

In reaching for outer space, man is indulging in a common human activity — extending his environment. Given enough time humans can adapt to environments of wide limits. The Eskimo, for instance, has evolved a frame which presents a minimum of surface area for a given body mass. This keeps loss of body heat to a minimum. The Peruvian Indian who lives at 17,000 ft and is capable of doing a good day's work at 20,000 ft illustrates that man is capable of adapting to lowered air pressure and oxygen intake.



PILOT REACTION to disorientation in space is tested in rig called MASTIF (Multiple Axis Test Inertial Facility). Three large gimbal cages allow free movement in every direction. Inner cage supports Mercury-type couch for pilot. Room is darkened during tests to remove references for orientation other than instrument panel.

Remarkable as the adaptations of the Eskimo and the Peruvian are, the challenges of manned space flight are of an entirely different order. One of the necessities in meeting this challenge is that the designer understand the complex nature of man. For, he must give man in the system everything necessary to sustain life. The designer must also see to it that man in the system is not subjected to injurious forces. These two criteria are the bare minimum.

Human morphology, or structure, must be taken into account in any man-machine space system. A vast amount of literature is available on human body size from measurements taken by physical anthropologists. The measurements are standardized, and based upon identifiable points on the skeleton. These measurements are not always directly applicable to the problems of the designer and have been supplemented by other measurements to solve specialized design problems. Of extreme interest are the measurements of workspace required for operators in various po-

BODY COUCHES in Mercury project are molded to each astronauts physical form. Foamed plastic and nylon webbing absorb shock and increase tolerance to G's. Science of measuring the human body must be expanded before multi-manned space stations can be designed adequately.

WORK-SPACE requirements are done on a "cut and try" basis in Mercury. Here, Scott Carpenter manipulates communications controls in rig designed by Collins Radio. Pressurized arm and glove allow testing without full suit.

sitions and at various tasks. These measurements must be taken for the population from which the man in the system is to be drawn.

The Human Form — The designer has learned to beware of averages. He is usually most interested in the range of any variable between the 5th and the 95th percentile of the population. This range is surprisingly limited when compared to the total range. Using Air Force data[1], the total range of stature is from 59.45 in. to 77.56 in. or 18.11 in. difference. The range between the 5th and the 95th percentile is from 65.2 in. to 73.1 in. or only 7.9 in. difference.

Design of special gear, such as space suits, requires precise knowledge of the human form. The Anthropology section at Wright Air Development Center has developed a method for the complete contour mapping of the human body[2]. This method utilizes stereoscopic photogrammetry. All astronauts have been photographed by this technique as well as being measured by more conventional methods. Dr. Sassouni at the University of Pennsylvania, working only with the face, has developed a similar technique which utilizes a single camera and the projection of grid lines by light directly on the subject[3]. This system could be adapted to the whole body if suitable projection methods were developed, and would have the advantage of eliminating the plotting of contour lines, as measurements can be taken directly from the photograph.

Mercury's Couch—In project Mercury, the astronauts themselves furnished the data for the contour couches of styrofoam. These couches were made from individual body impressions. The couch was selected as the type of support most likely to distribute the body weight evenly under acceleration. Actually, pressure distribution will depend to a large extent upon the structure of each astronaut's skeleton. The Mercury couch is not the ultimate in the design of a receptacle for the human body under high dynamic loading. The couch, to mention just one shortcoming, does not change its shape to allow for both inflation and deflation of the space suit.

Knowledge of biomechanics is also essential in the design of control devices and space suits. Knowledge of the human center of gravity is an absolute necessity in any system where the weight of the man is a high proportion of the weight of the total system. The effects on the stability of such a system due to movements of the body is also of interest. Much of the relevant data on biomechanics can be found in Hertzberg[4], Dempster[5], and Barter[6].

Human Tolerance—In Project Mercury, bioelectronic means will be utilized to obtain a record of such variables as heartbeat, breathing, galvanic skin response and others.

Research on various human limits has been underway for a

Tolerance to 45 instantaneous G's demontsrated; Heat, lack of oxygen lower this level

number of years. Pilots have been subjected to the effects of high acceleration, reduced oxygen pressure, changes in ambient temperature and other hazards since the development of high performance, high altitude aircraft. The accelerations expected in the launch, reentry and impact stages of a space mission are beyond these "normal" flight conditions. They are not, however, beyond the experience of human subjects on centrifuges and rocket sleds.

Tolerance to acceleration depends upon: (1) The direction in which the accelerating force is applied to the body; (2) The magnitude of the accelerating force; (3) How long the accelerating force is applied; (4) How rapidly the accelerating force is applied; and, (5) How the body is supported during the acceleration.

The forces involved in sternumward acceleration can be visualized as those which would occur if the occupant of a chair were propelled forward. Spineward accelerations can be visualized as those which would occur if the occupant of the chair were propelled backward. Headward acceleration would occur if the direction of movement was upward, and tailward acceleration would occur if the direction was straight down. The tolerance to tailward acceleration is lowest, as it results in a rush of blood to the brain and eyes, causing "redout." Voluntary exposures in this position are 10 G for 0.004 sec and 7 G for 0.4 sec. Indications are that tolerance limits are higher than the voluntary exposure, a chimpanzee was exposed to a peak of 22 G's at an onset rate of 1400 G's/sec without injury. This was in the supine position with adequate restraints. Normally, this type of acceleration would be experienced only in downward ejection.

BIOELECTRONIC DEVICES will measure body reaction in space environment. First atsronauts will have "pick ups" taped to, and inserted in skin. "Belt system" shown is development of Boeing where orbital glider, Dynasoar, is being designed and developed for Air Force.

Beyond the Voluntary—Headward acceleration has been tolerated at an onset rate of 1300 G's/sec to a peak magnitude of 12 G's which was described as a severe jolt. At lower onset rates, with lap and back straps and arm rests, higher peaks can be tolerated. The limits for current ejection seats are above the voluntary exposure in this position. If injury is to be avoided in this position, the spine must be kept straight, and the head supported.

Voluntary tolerance to spineward accelerations of 45 G's for 0.044 sec at an onset rate of 500 G's/sec have been reported[7]. The limit decreases to 40 G's for 0.1 sec, and to 25 G's for 0.2 sec at this onset rate. Exposures of 13 G's for 0.6 sec and 10 G's for 1.6 sec can be tolerated at the same onset.

Sternumward acceleration is of the greatest interest in the design of space-craft, because adequate body support is most easily provided in this position. On the rocket sled, with a padded seat, and with arms, head, and legs held in place, human subjects have voluntarily exposed themselves to 35 G's for 0.1 second[7]. This exposure represented a complete stop from 72 mph in a distance of 8.2 ft. Tolerance in this

position is believed to be similar to that of spineward acceleration.

Tests conducted at Johnsville on the human centrifuge with the contoured couch indicate that reentry accelerations as high as 25 G's can be successfully negotiated by a trained subject[8]. At this acceleration it is still possible for the pilot to operate a small right hand control stick. In these experiments and the training runs of the Mercury astronauts, several different techniques are used to get optimum G tolerance. It has been found that a pressure suit, or anti-G garment, can increase tolerance by one or two G's. If the man strains his muscles G tolerance gets an additional boost. Combining the two methods, tolerance can be increased by as much as 4 G's. Another factor in the high G tolerances is optimal positioning. In the Mercury capsule, the astronaut will be in a semi-reclining position, with knees raised and body at an angle of about 80 deg from the vertical. The contour couch will also afford some protection from oscillation.

Effects of Temperature—This data might make it sound as though the 9 G reentry maneuver expected in Mercury is nominal. But there are other factors in reentry to be taken into consideration. First, there is the danger of a sharp rise in temperature. Tolerance to acceleration begins to drop when ambient temperature reaches 100°F. At this temperature there is a 0.2 G loss. As temperature increases, the loss of tolerance increases until at 160°F, the highest temperature tested, the loss is 1 G. In this experiment, the accelerations used were from 4 to 5 G's, considerably lower than those expected in space flight. A reduced oxygen level also has a depressing effect upon G tolerance.

Weightlessness—Another factor of unknown magnitude in space flight will be the effect of acceleration after weightlessness. The effect of weightlessness itself over a period of time is unknown, as it is impossible to simulate weightlessness except for short periods. Experiments in a converted C-131 have allowed study of the weightless state for 12 to 14 sec. In the F-104, it is possible to induce weightlessness for about 35 or 40 sec. A KC-135 has recently been converted for weightless studies at WADC. Von Bekh[10] in 1953 experimented with the effect of weightlessness upon acceleration tolerance by exposing subjects to a weightless state and then maneuvers involving G forces. Subjects normally tolerating 5 G's could only tolerate from 3.5 to 4 G's. What the effect of longer periods of weightlessness will be upon G tolerance remains to be seen.

WEIGHTLESSNESS, one of the greatest unknowns in space flight, cannot be simulated on earth. Parabolic curve is flown in specially equipped aircraft to give 15 to 30 sec of weightlessness at a time. Newest "lab" is converted KC-135.

The protection of the man upon impact is also a consideration. In Mercury, this protection is afforded by a crushable aluminum honeycomb structure[11]. The aluminum honeycomb has the advantage of not rebounding. The amount of force needed to start the collapsing action can be controlled by varying the surface area.

Man's Atmosphere—An important consideration in designing a sealed space cabin is the selection of an atmosphere. Most authorities agree that the ideal environment would be the normal sea level composition and pressure of the air. But, a lower cabin pressure is desirable from an engineering viewpoint, since the problems of maintaining leak free seals are reduced. In Mercury, the pressure selected is 5 psi, and 100 per cent oxygen, which can be seen to be adequate, as 100 per cent oxygen is required at 2.78 psi. For longer flights than Mercury, a pure oxygen environment would be undesirable because of the adverse effects of pure oxygen on the body.

In a sealed cabin, products of respiration must be prevented from contaminating the atmosphere. Air can be recirculated if carbon dioxide is removed by lithium hydroxide. Absorption methods are feasible for short periods. A pound of lithium hydroxide will absorb about one pound of carbon dioxide. The amount of carbon dioxide produced by man in a day is about 2.5 lb. The consumption of oxygen is about 2 lb per day. Carbon dioxide concentration should be maintained below 1 per cent. The Mercury system uses lithium hydroxide to absorb carbon dioxide, activated charcoal absorbs other impurities,

Man in the system introduces many problems, but he is most flexible component

and sponges absorb water. Relative humidity in a space cabin should be maintained between 50 per cent and 70 per cent.

Temperatures between 70°F and 90°F are comfortable. The highest limit of temperature for one hour is 130°F; the lower limit for the same period is 40°F. Higher or lower temperatures could be tolerated easily with protective clothing.

Beyond Mercury—Although the environmental system for Project Mercury is adequate for a short period, longer space flight will require other methods. In the long run, it appears that the closed ecological cycle would be the most economical for extended voyages. The problem of the recirculation of water from urine is handled by General Electric by pyrolysis under vacuum conditions. The urine is vaporized by boiling, and the vapor is passed through a high temperature pyrolizing zone to eliminate toxic materials and then condensed. Much research is being done on gas exchange utilizing algae. The algae absorb carbon dioxide and produce oxygen. Theoretically, it should be possible to feed the algae solid wastes from the body, and utilize the algae for food. Formidable problems exist in the design of such a system.

A sealed cabin will have to be protected from the impacts of micrometeorites[12]. Fortunately, as the size of particle increases, the frequency decreases. Explorer VI was hit by 28 micrometeorites in the first two days of orbit[13]. Whipple has pointed out the need for more knowledge in this area. One area for investigation is the characteristics of the orbits of meteoritic material in space. The major danger to man involves the possible loss of atmosphere through puncture of the space capsule. Another danger is the erosion of optical surfaces and other outside installations.

Radiation Dangers—Radiation surrounding Earth has complicated the problem of space flight considerably[14]. The radiation area starts at about 600 mi from Earth and extends to 35,000 mi. Peak intensities are encountered at 2500 and 10,000 mi. Indications are that the outer belt is subject to fluctuations dependant upon solar activity. Biological exposure rates in the two zones may be of an order of about 5 to 10 roentgens/hr. Early manned flights will not penetrate the radiation zones. Trapp and Konecci[15] have proposed in a recent paper the utilization of sustenance materials as part of a radiation shield for an atomic powered space ship.

Shielding for space ships is complicated by the existence of cosmic rays. The penetration of shields by primary particles could cause heavy secondary emissions. Further information is needed on how cosmic rays affect biological organisms.

The radiation belts are doughnut shaped, and do not extend over the poles. This may be the answer to an escape corridor, but there are problems connected with a polar launch. The existance of a radiation belt around Earth also means that there may be radiation belts around the other plants which would also complicate the problems of space flight.

Does Man Fit?—With all the problems which man introduces into the design of a space vehicle, why put him there? What are some of the advantages of having a man in the system? One advantage lies in the flexibility of man as a component of a system. To use this flexibility in increasing system reliability the designer should keep as many parts of the system available for in-flight repair as possible. The use of easily replaced modules would be a great advantage. Another factor which would make for repairability would be to utilize as few different components in the system as possible, combining them in different ways to attain system goals. To provide maximum utilization of the man, those selected for space missions should participate in the design and fabrication of their own vehicle. This also has the advantage of increasing motivation. ✦

REFERENCES

1. *Anthropometry of Flying Personnel—WADC TR 52-321.*
2. *Hertzberg, Dupertuis & Emanuel —Photogrammetric Engineering, December 1957.*
3. *Journal of Forensic Sciences, pp. 432-35, Ocotber 1957.*
4. *Annotated Bibliography of Applied Physical Anthropology in Human Engineering—WADC TR 56-30.*
5. *Space Requirements of the Seated Operator—WADC TR 55-159.*
6. *Estimation of the Mass of Body Segments—WADC TR 57-260. See also N. A. Bernstein et al, Determination of Masses and Centroids of Segments of Human Body on Live Subjects VIEM, Moscow 1931 (in Russian).*
7. *A. Martin Eiband, Human Tolerance to rapidly applied Accelerations—NASA MEMO 5-19-59E.*
8. *C. H. Woodling and C. C. Clark, Studies of Pilot Control During Launching and Reentry of Space Vehicles, Utilizing the Human Centrifuge. IAS report No. 59-39.*
9. *B. Burgess, The Effect of Temperature on Tolerance to Positive Acceleration ASME Paper No. 59-A-212.*
10. *Astronautics, February 1959.*
11. *NASA TN D-158.*
12. *Fred L. Whipple, Meteoric Material in Space—Smithsonian Astrophysical Observatory and Harvard College Observatory.*
13. *NASA Release No. 59-201.*
14. *J. Van Allen & Louis A. Frank, Radiation Measurements to 658,-000 Kilometers with Pioneer IV —State University of Iowa.*
15. *American Astronautical Society Preprint No. 59-2.*

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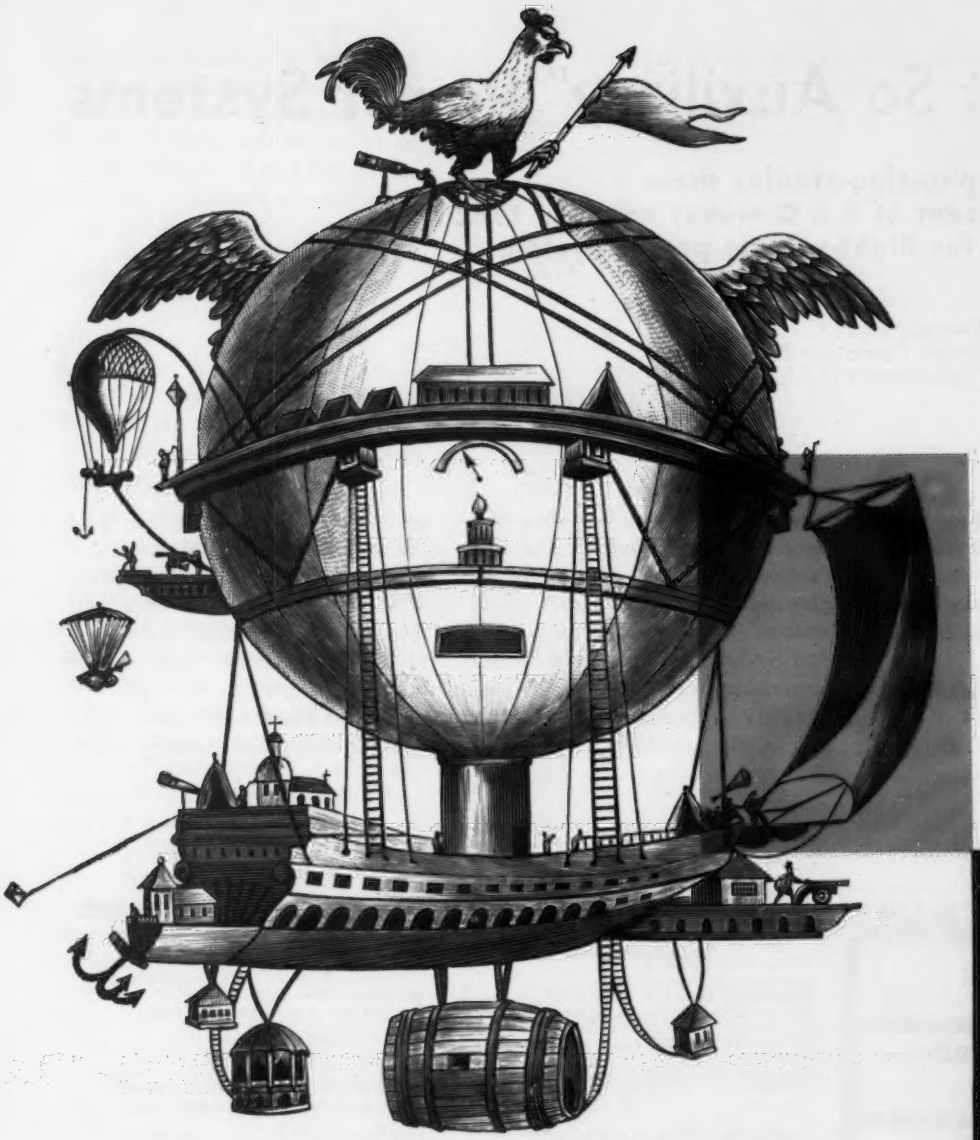

M. Marey Monge made no attempt to keep imagination in check when he conceived this military balloon in 1800. Complete with sail, the "dream" balloon was supposed to support an army of 4,000 in every way for months at a time. In this wood engraving, Brussel-Smith has included the most minute details of Monge's ambitious project.

IMAGINATION IN SPACE—Since Creation, man has looked out on space. At first, unknowing and incurious; then with the beginnings of understanding; now free and able to explore. Yet to move in space calls for wholly new concepts of energy.

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The "Not So Auxiliary" Power Systems

WADD planning-studies show 10 per cent of R & D money spent in 1962 will be for flight-vehicle power systems

By H. R. Shows, Chief
Plans & Technical Operations Branch
Wright Air Development Division

The most important function of any organization is proper planning. And, the most important decision a manager makes is the way he decides to use the resources assigned to him.

At WADD, Flight-Vehicle Power has been the object of some long, hard looks by the planners. This area encompasses what was once called "auxiliary" power, and "secondary" power. Because of the growing significance these power systems Navy, Air Force, Army and NASA have dropped the latter terminologies, there is nothing auxiliary or secondary about their role or the attention they are receiving. Air Force has increased research funding in this technical area 16 fold in the past three years. WADD and ARDC have revamped their research organization to bring Flight-Vehicle Power Systems into proper perspective.

Like A Puzzle—Keystone of the WADD long-range planning is the

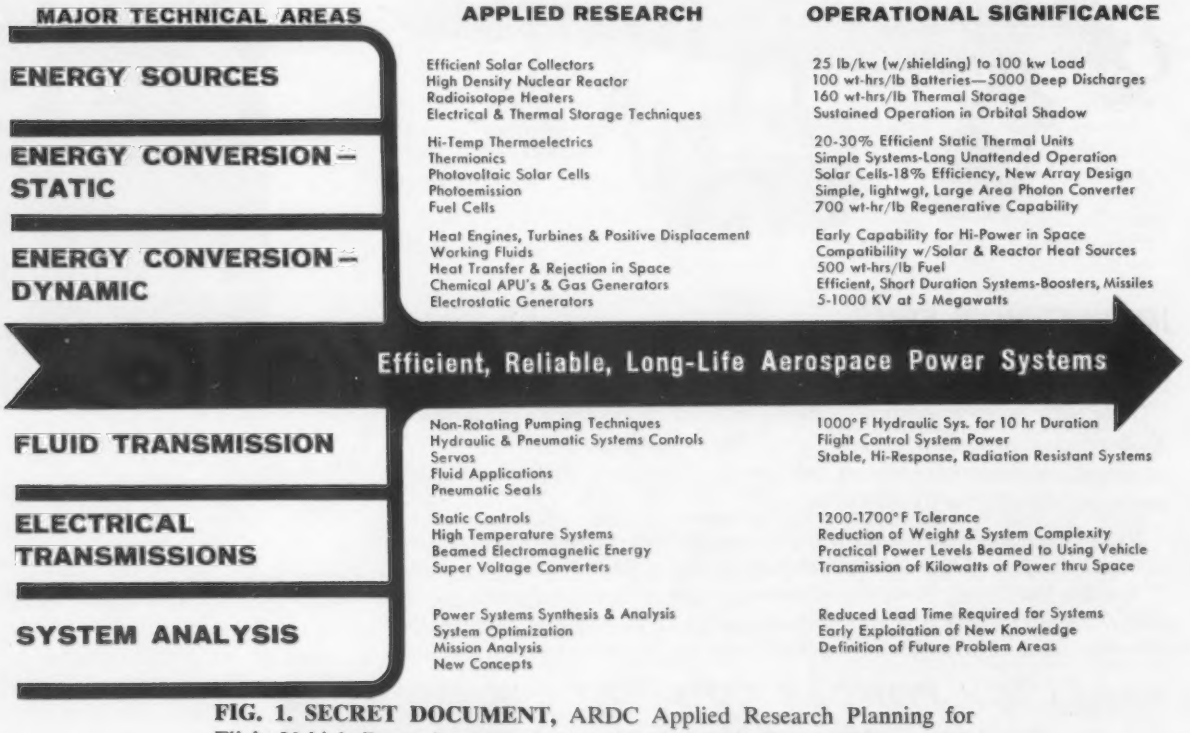


FIG. 1. SECRET DOCUMENT, ARDC Applied Research Planning for Flight-Vehicle Power is summarized in this chart. Six major work segments are shown at left. Type of research in each segment, and its significance are in adjoining columns.

"allocation model." It was developed to give management a systematic method of assigning manpower, facilities, and money to expedite research. It provides a master plan: In concept it is not unlike securing a completed picture before attempting to piece together a jigsaw puzzle.

The results of the study show that of the 25 areas being researched at WADD, Flight Vehicle Power falls within the top five. By 1962 about 10 per cent of all research funds expended will be in this area.

In constructing the allocation model, the entire technical area of Flight Vehicle Power was subdivided into six segments called "work segments." Each work segment was given a time oriented goal and specific numerical ratings. By mathematics, an overall index for each work segment was established. The complete mechanism of this system is best described in the ARDC Applied Research Planning Document for Flight-Vehicle Power; the document is classified SECRET. It is summarized in Fig. 1. The six work segments are shown with the type of research going on in each segment. The operational significance of this research is shown in the right hand column of the figure.

Fig. 2 shows the significance of each work segment on projected Air Force weapons systems. The details of the evaluation are cumbersome and are contained in classified documents.

Deficiency, Cost, Potential—In projecting the results of research three factors are considered: (1) Deficiency, (2) Potential, (3) Cost.

Deficiency is the factor which decides the rate of increase in resources that must be applied to get a capability by the time it is required.

Cost is established by multiplying the deficiency factor by the estimated national expenditure in any area during fiscal 1960. Fig. 3 illustrates roughly how the WADD evaluation sees funding in the six work segments in the next 20 years.

EFFECT OF FLIGHT VEHICLE POWER ON FUTURE VEHICLES

WORK SEGMENTS	BALLISTIC MISSILES	AERODYNAMIC MISSILES	AIRCRAFT	BOOST GLIDE	SATELLITES	LUNAR FLIGHT	PLANETARY
ENERGY SOURCES	0	3	3	3	7	8	8
ENERGY CONVER. STATIC	0	2	1	3	8	8	8
ENERGY CONVER. DYNAMIC	3	6	5	7	6	6	7
FLUID TRANS.	3	7	7	8	5	7	6
ELECT. TRANS.	3	6	7	7	7	7	7
SYSTEM ANALYSIS	1	3	3	5	7	8	8

VEHICLE TYPES

Definition of Rating

Numerical Rating	*Adjective Rating*
9	*Essential* to attainment of design mission capability and will permit *revolutionary improvement* of performance beyond the design mission capability.
7	*Essential* to attainment of design mission capability and would provide *adequate* performance for the design mission capability.
5	*Essential contribution* toward attainment of design mission capability but would provide performance *significantly less than desired* for the design mission capability.
3	*Not essential* to attainment of design mission capability but would permit *small improvement* beyond design mission capability.
2	*Not essential* to attainment of design mission capability but would provide *economy and/or convenience* to the design mission capability.
0	Negligible improvement.

FIG. 2. EFFECT OF RESEARCH on projected Air Force vehicles is part of WADD planning model for flight-vehicle power. Work segments are given a numerical rating. Total import of each work segment can be obtained by adding figures in each column.

Potential is the foreseeable probability of further technological advancement in a work segment toward objectives 5 years beyond the time of the study. Fig. 4 shows the results of the WADD study. The potential of fluid transmissions is seen as limited beyond 1977 since "few areas of refinement will exist."

Future Plans—Air Force will rely on industry to carry hardware to the production stage through competition. Research funds will be used for untried unique techniques where risk is high but payoff is great. The increase in budget will go mostly toward proving feasibility of building packages to operate as a subsystem. This will reduce lead time. But, most important, it will take hardware to a place where industry will pick up the program and prepare it for production.

There are several holes in the area that need to be plugged.

The Nuclear Reactor—To provide an optimum reactor for a particular application will require approximately six years. In order to use nuclear power as an energy source for any manned military vehicle started in the next two years, essentially present-day reactors must be scaled up or down. This can only result in heavy installations, inadequate shielding, and unreliability. Demonstration and exploratory unmanned vehicles started

Nuclear studies, heat rejection, and zero G conditions biggest challenge

within the next four years must use present scaled nuclear energy sources. Building an optimum nuclear source is the longest lead time item for sophisticated military vehicles, and this is the item receiving the least financial support.

Systems—The factor which most hurts support for nuclear energy sources is lack of sound analysis and synthesis of projected military vehicles. Air Force has not convincingly synthesized an advanced vehicle that justifies the Atomic Energy Commission to start such a development. Intuitively, we all know generally what is needed; however, this has not been reduced to practical justification. The user has to furnish desired power characteristic inputs at an earlier date for advanced system. However, most important is the need of taking the most advanced energy source, conversion and transmission technology and converting them into mathematical equations for use in system studies. The overall system study will provide valuable technical guidance for advanced research.

Heat Rejection — The most critical item of all energy conversion is dumping waste heat overboard in space. Practically all conversion methods are limited by the Carnot cycle efficiency, which means dumping overboard 50 to 70 per cent of energy aboard the vehicle. The only way known to do this is by radiators that must be stored in small space during the boost phase of the vehicle, operate at extremely high temperature for maximum effectiveness, withstand meteorite punishment, and operate at weightless conditions.

Information Exchange—To expedite the already fast pact, the services must discourage unwarranted duplication. This can best be accomplished through a Power Information Center (PIC).

Army organizations, operating under the auspices of the Interservice Group for Flight Vehicle Power (IGFVP) are presently preparing a request for bid for a Power Information Center. It is assumed that this will be a captive government organization such as a nonprofit research organization or institution.

Contractors with an established "need-to-know" will receive reports and briefs of work in his area of interest. The full cooperation of Industry will soon be solicited.

Zero Gravity Tests — Unfortunately, we know of no way of sustaining Zero "G" conditions in a test laboratory. Make shift simu-

WHO'S WHO IN RESEARCH

Contract No.	Contractor	Nature of Contract
AF33(616)-5955	AiResearch	Prove feasibility of building solid propellant 40 HP/20 min range power units.
AF33(616)-5755	Solar	Prove feasibility of building 100 HP range atmospheric chemical power unit to operate at 1000°F and 100,000 ft.
AF33(616)-6421	Sundstrand	Prove feasibility of closed loop/long duration H_2O_2 Rankine cycle engine utilizing sulphur as working fluid driving turbine.
AF33(616)-5432	Thompson	Design criteria for hydrazine gas generator utilizing thermodecomposition.
AF33(616)-5433	Walter Kidde	Provide aerodynamic and thermodynamic performance data for small, high speed multi- and single-stage partial admission turbines.
AF33(616)-2936	Sundstrand	Design criteria for cermets applied to turbine wheels.
AF33(616)-6625	Thompson	Prove feasibility of 1 to 6 KW solar dynamic power unit (SPUD I)
AF33(616)-6624	AiResearch	Study advanced solar dynamic power systems of 1 to 30 KW range with special emphasis on 15 KW.
AF33(616)-6612	Westinghouse	Improved solar cells with 15 per cent efficiency,
AF33(616)-6707	Shockley	Silicon solar cell parametric study
AF33(616)-6615	RCA	Galium arsenide solar cells.
AF33(616)-5218	General Electric Co.	Materials and techniques for thermopile generator.
AF33(600)-34709	Patterson Moos	Prototype fuel cells using H_2O_2.
AF33(616)-6399	Resin Research Lab.	Organic fuel cell system.
AF33(616)-6585	Sundstrand	Solar regenerative fuel cell.
AF33(616)-	Thompson	Nuclear regenerative fuel cell.
AF33(616)-6617	Hoffman	Solar cell—100 Watt (500 Watts Peak) power package.
AF19(604)-5472	General Electric Co.	Basic research on improving efficiency of thermionic converters. Monitored by AFCRC.
AF33(616)-5815	AiResearch	Closed cycle—single loop nuclear conversion system.
AF33(600)-39357	Hallamore	Variable speed constant frequency alternator.
AF33(600)-36810	A. C. Kirkwood	Fixed engine generator sets, 200 to 2000 KW.
AF33(600)-38077	Armour Research	Develop light weight gas turbine generator sets for TAC.

lations provide only a very short time period (from a fraction of a second to possibly 15 to 30 sec for expensive towers under controlled conditions). Another method in use is flying the test setup through a parabolic flight maneuver and getting about 7 to 15 sec of weightless condition. This has been accomplished with a C-131 at WADD.

The next step will be the use of a KC-135 aircraft for these Zero "G" tests. It will provide up to 30 sec of the weightless condition. First flights were conducted this spring.

✦

SELECTED REFERENCES

Based on a recently cleared paper, "Planning The Air Force Research Program For Space Flight Power," presented at Vickers 9th Annual Hydraulics Conference.

(1) Secondary Power and Accessory Problems for Tomorrow's Air Weapon Systems; H. R. Shows; ASME Paper No. 57-A-296; December 1957.

(2) ARDC Applied Research Planning Document for Flight Vehicle Power (FY 1961 Operating Program)—AF ARPD 750F; Published by Hq ARDC, ATTN: RDRAPP, Andrews Air Force Base, Washington 25, D. C. (Copies have been forwarded to most Air Force contractors involved in Flight Vehicle Power; the document is classified Secret.)

(3) Technology for Tomorrow (1960 Edition) Long Range Research Planning for WADC: Plans Division, DCS/Plans and Operations (WCOP); the document is classified Secret.

(4) The WADC Effort Allocation Guide: WCOP Technical Memorandum 59-1; Howard A. Wells, John R. Cannon, Carl L. Oakes, Jr.; Plans Division, DCS/Plans & Operations; the document is classified Secret.

(5) Flight Vehicle Power; Colonel R. A. Jones and J. S. Keeler; SAE Paper 105U; October 1959.

(6) WADC Fluid Tests under Zero Gravity Conditions; film produced by WADC using C-131 aircraft as flight test bed obtaining up to 15 seconds weightless condition; project engineer, Don Lowe, WCLP, WADC.

(7) Procedure Forthcoming; may be obtained by writing WADC, ATTN: WCLOX, Mr. J. H. Slavan, Wright-Patterson Air Force Base, Ohio.

A REPRINT

of this article can be obtained by writing on company letterhead to The Editor, AIRCRAFT & MISSILES, Chestnut & 56th Sts., Phila. 39, Pa.

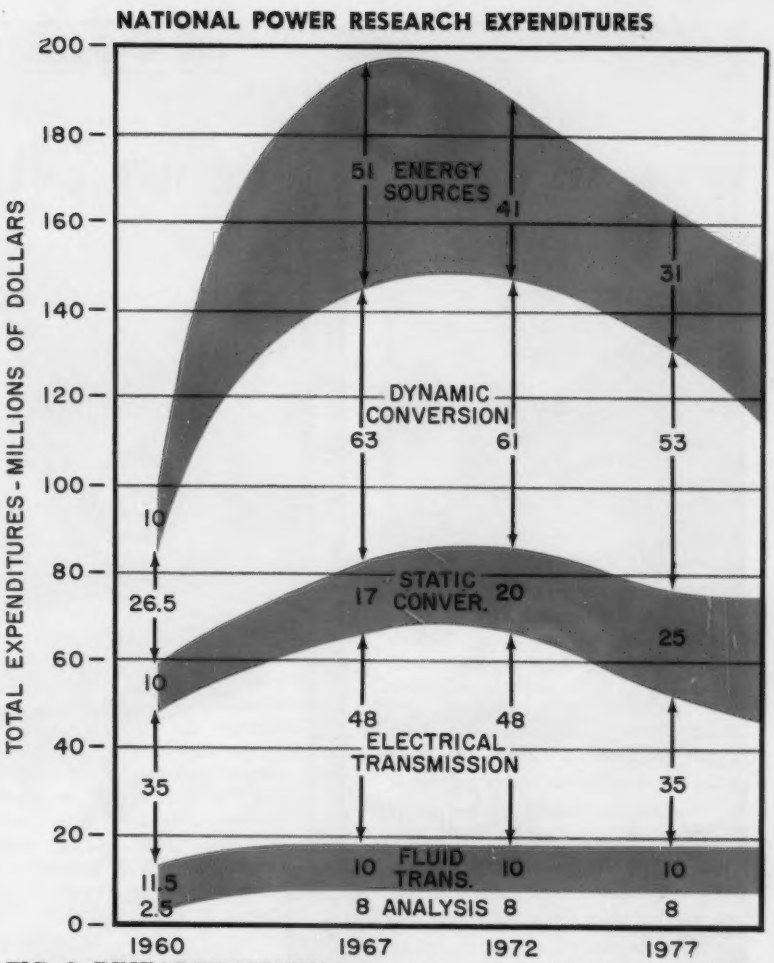


FIG. 3. RESEARCH MONEY for power research should peak at $200-million in 1967 according to WADD. Numbers in graph indicated millions of dollars to be spent in each work segment per year.

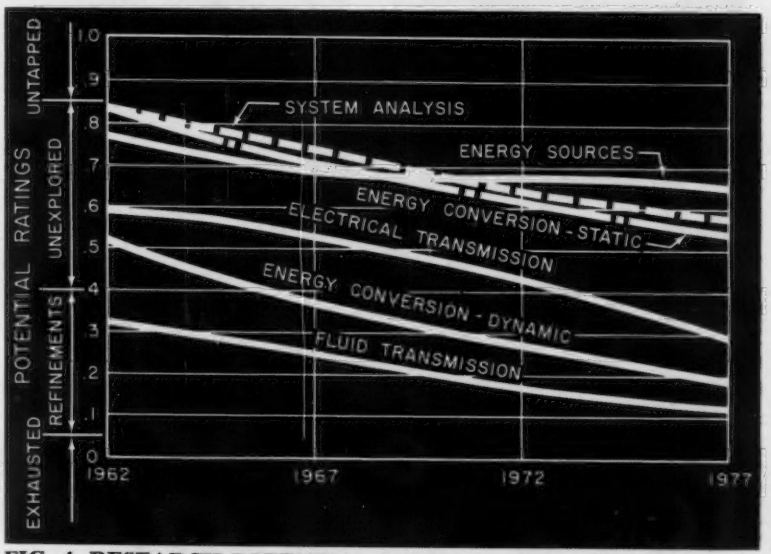
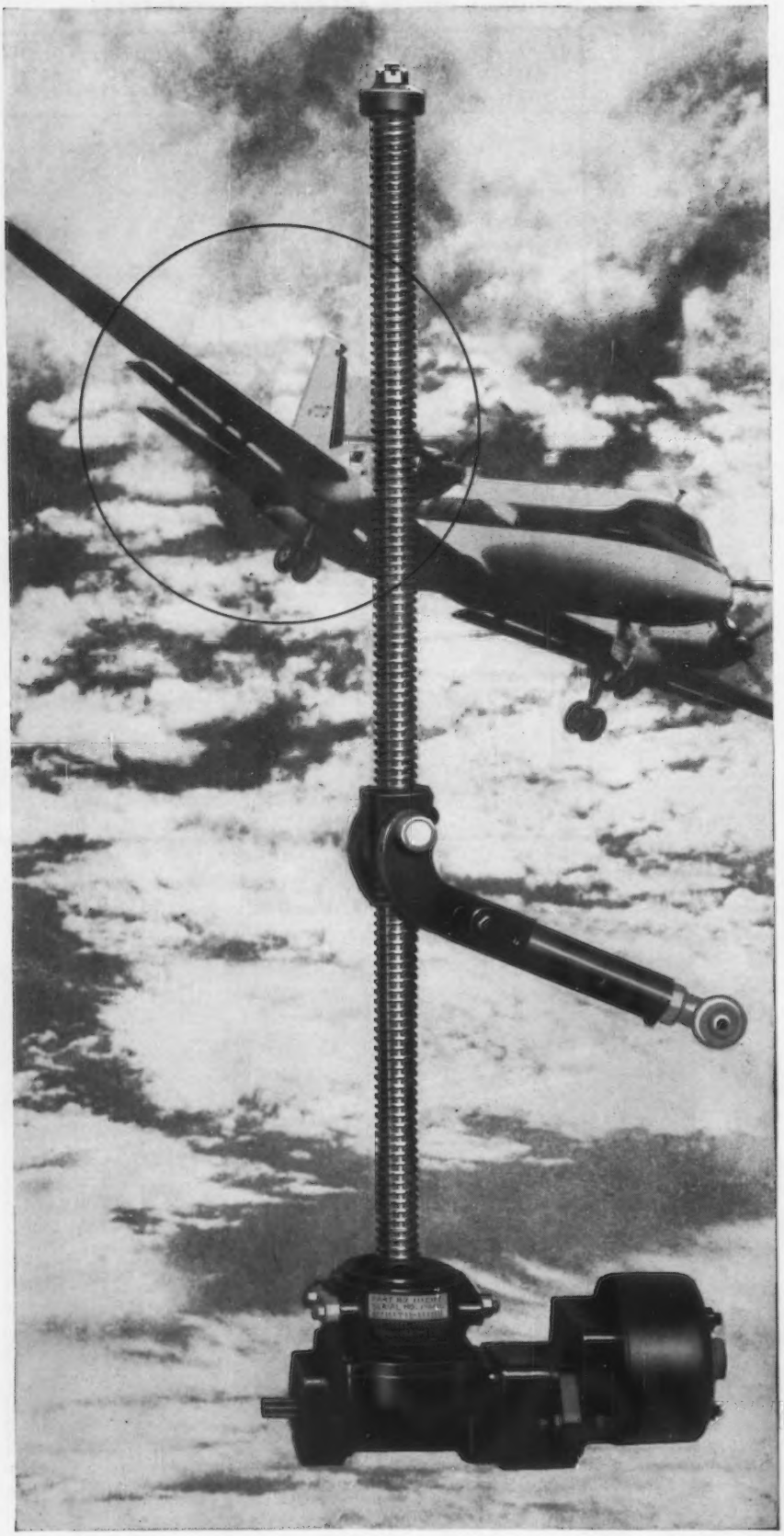


FIG. 4. RESEARCH POTENTIAL is rated as a factor of probability for technological advancement. In some work segments there is room for much refinement, in other foreseeable potential is exhausted.



Grumman Gulfstream

newest business aircraft equipped with Kelsey-Hayes wing-flap actuators

This new twin turbo-prop business airplane carries up to 12 passengers in pressurized comfort well above 30,000 ft. and at airspeeds exceeding 350 mph.

Capable of operating from short runway airports, Gulfstream gets its wing flap action from a hydro-mechanical actuation system designed and produced by our SPECO Division in Springfield, Ohio.

SPECO, supplier to the aircraft industry for over 40 years, also produces helicopter transmissions, lightweight special hoists, precision radar antenna mounts, precision gears and gear assemblies for the aerospace industries. Kelsey-Hayes Company, Detroit 32, Michigan.

KELSEY HAYES COMPANY

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18 PLANTS: Detroit and Jackson, Michigan; Los Angeles; Philadelphia and McKeesport, Pennsylvania; Springfield, Ohio; New Hartford and Utica, New York; Davenport, Iowa; Windsor, Ontario, Canada.

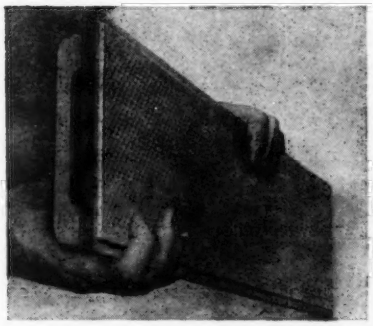
Important facts to know about Laminated Plastics

LAMINATED PLASTICS *What they are, where they can be used*

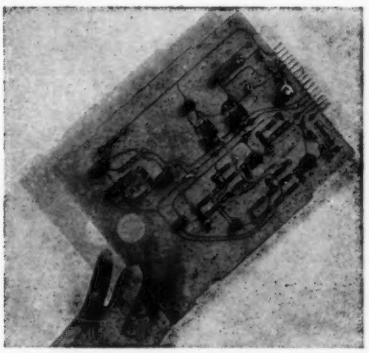
Taylor laminated plastics, also known as reinforced plastics, are thermosetting-type materials formed by impregnating paper, cotton cloth, asbestos, glass cloth, nylon or other base materials with synthetic resins and fusing them into sheets, rods, tubes and special shapes under heat and pressure. These materials exhibit a valuable combination of characteristics, including high electrical insulation resistance, structural strength, strength-to-weight ratio, and resistance to chemical reaction; also adaptability to fabricating operations.

Types of laminated plastics made by Taylor
There are four basic types of Taylor laminated plastics commonly specified and used throughout industry today. They are as follows:

Phenolic Laminates. Paper, cotton fabric or mat, asbestos, glass cloth or nylon bases impregnated with phenol formaldehyde resins. These provide strength and rigidity, dimensional stability, resistance to heat, chemical resistance, and good dielectric characteristics. Some Taylor grades are excellent basic materials for gears, cams, pinions, bearings and other mechanical applications. Others are widely used in terminal boards, switchgear, circuit breakers, switches, electrical appliances and motors. Also in radios, television equipment and other electronic devices; and in missiles as nose cones, exhaust nozzles, and combustion chamber liners.

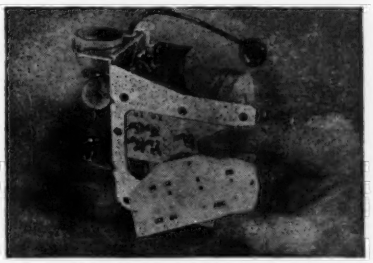


Melamine Laminates. Glass cloth or cotton fabric impregnated with melamine formaldehyde resin. Taylor melamine laminates have superior mechanical strength and are especially desirable for their arc-resistant qualities. Good flame and heat resistance, good resistance to the corrosive effects of alkalis and most other common solvents, besides other favorable characteristics. Typical applications include arc barriers, switchboard panels, and circuit-breaker parts in electrical installations.



Silicone Laminates. Continuous-filament woven glass fabric impregnated with a silicone resin. These laminates combine high heat resistance (up to 500°F. continuous) with excellent electrical and mechanical properties. They are primarily used in high-temperature electrical applications and high-frequency radio equipment.

Epoxy Laminates. Continuous-filament woven glass fabric or paper impregnated with epoxy resin. Glass-fabric grades are designed for use in applications requiring high humidity-resistance, good chemical resistance,



and strength retention at elevated temperatures. Paper grades are used under high-humidity conditions where resistance to acids and alkalis is required. Both grades are characterized by good dielectric strength, low dielectric losses, and high insulation resistance even following severe humidity conditions.

• • •

Recent technical advances in the bonding of various metallic and nonmetallic materials to laminated plastics have opened up new design opportunities. It is now possible to bond virtually any compatible material with a laminated plastic to form a composite which combines the advantages of both. One of the first composite materials was a copper-clad laminate used for printed circuits. More recent composite laminates, usually manufactured to customer specification, include the following: Taylorite® vulcanized fibre-clad, rubber-clad, asbestos-clad, aluminum-clad, beryllium-copper-clad, stainless-steel-clad, magnesium-clad, and silver- and gold-clad. Any one of these materials can be sandwiched between sheets of laminates, too, and can be molded to fit specific requirements.

Send for complete information about any or all of these Taylor laminates. And remember Taylor's new selection guide will simplify your problems in choosing the right laminate for your specific application. Taylor Fibre Co., Norristown 50, Pa.

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LIQUIFLOW*: CAPACITY UNLIMITED, EFFICIENCY UNEQUALED

The Stewart-Warner Corporation relies on low-cost, flexible CO_2 for the rigid testing during development of fuel preheaters for SAC's Jet Bombers

Jet bombers for the Strategic Air Command—vital cogs in a vast program to assure safety and security for every American. The South Wind Division of the Stewart-Warner Corporation of Indianapolis, Indiana, tested fuel preheaters intended for SAC's jet bombers, simulating environmental conditions from ground level to 60,000 feet.

The logical choice of refrigerant for these tests: Liquiflow.

Stewart-Warner found this CO_2 system preferable to all others for four major reasons:

1. Lower initial investment—a mechanical unit of comparable output would be so large that the cost would be prohibitive.
2. Unlimited refrigeration capacity—Liquid Carbonic's permanent Liquiflow storage tank, local plant and supply trucks offer an abundance of liquid CO_2 whenever needed.
3. The unique design of the installation provides rapid pulldown, reduces engineering man-hours and manual labor with no breakdown worries . . . no maintenance.
4. Versatility—Stewart-Warner's environmental program includes an altitude chamber, product testing, temperature testing, and negative and positive pressure testing—all with the use of Liquiflow.

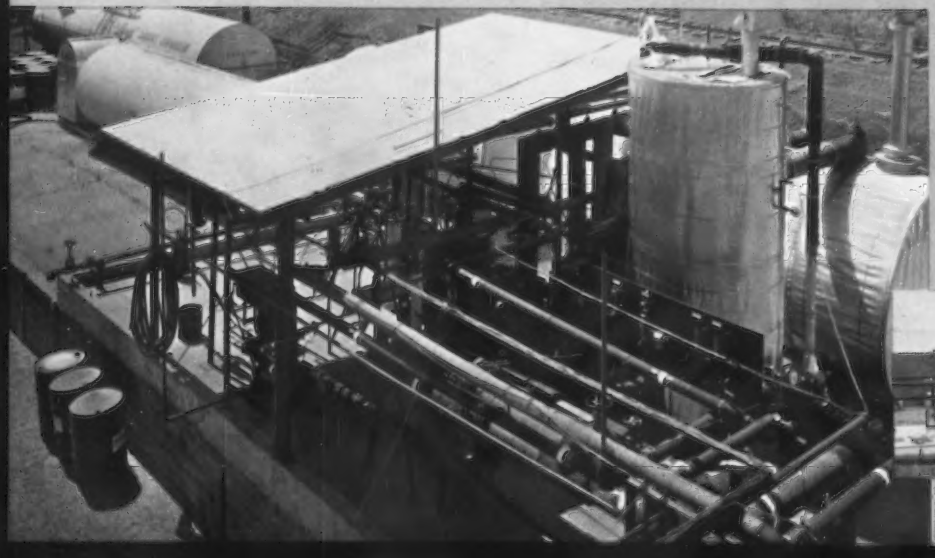
CO_2—ideal for "crash" programs

Stewart-Warner was given just one month to meet the specifications for the tests; in that time, thanks to the combined efforts of Stewart-Warner and Liquid Carbonic engineering teams, the installation was designed, installed, and ready to go.

The Problem: Government specifications required that the fuel be prepared at 100° F., with maximum water saturation. Next, the temperature of the fuel was to be lowered gradually to −70° F. over a period of 13 to 14 hours. Water was to be injected periodically to assure ice crystals, and the fuel sampled every 15 minutes for ice. Finally, the fuel was to run through the heat exchanger at 250 to 2000 gallons per hour, and emerge at a temperature range of 32° to 47° F.—with no ice.

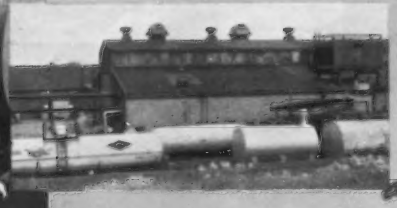
The solution: Stewart-Warner's first step was to heat the 5000 gallons of fuel to 100° F.; next, for

*Liquiflow is Liquid Carbonic's registered trade-mark for liquid carbon dioxide systems.



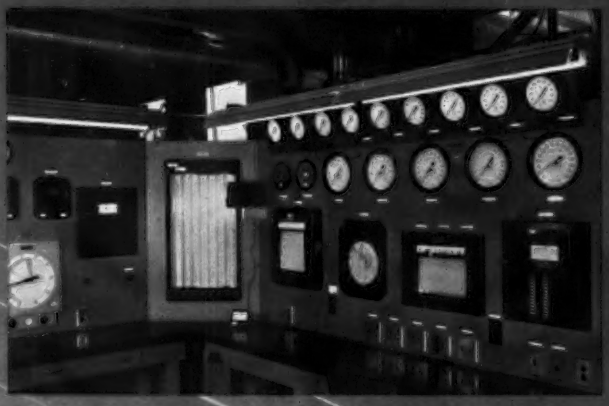
Testing site: Liquiflow installation at upper left; fuel tank at upper right. Pipes transport Liquid CO_2, water and fuel to testing tank.

Liquiflow Installation: Stewart-Warner's assurance of an always ample supply of carbon dioxide; rail car delivery provides auxiliary supply.



Testing chamber: the site of all negative and positive pressure tests. Liquiflow tank in lower right for immediate supply.

Control headquarters: using this comprehensive control panel, Stewart-Warner carefully tracks the progress of all tests.



every 1000 gallons of fuel, six pints of water were to be added. The fuel was to settle for eight hours, after which the excess water was to be drained off.

A CO_2 snow tube was inserted in a sublimation tank containing 1000 gallons of alcohol. The alcohol then traveled to a fuel conditioning tank, gradually lowering the fuel temperature. The entire operation required from 17,500 to 18,500 pounds of CO_2.

In using Liquiflow—Stewart-Warner has increased efficiency, cut costs and simplified its operation, and was able to start on its qualification tests of equipment just one month after receipt of the specifications. If low-temperature environmental testing is in your present or future plans, let Liquid Carbonic's engineers work with you. One of Liquid Carbonic's many supply depots is near you to assure you of fast, efficient delivery. Call your Liquiflow representative today—he is trained to solve your problems!

Liquid Carbonic is a Major Producer of Compressed Gases: Oxygen, Acetylene, Nitrogen, Hydrogen, Argon, Carbon Dioxide, Nitrous Oxide, Helium and Various Gas Mixtures.

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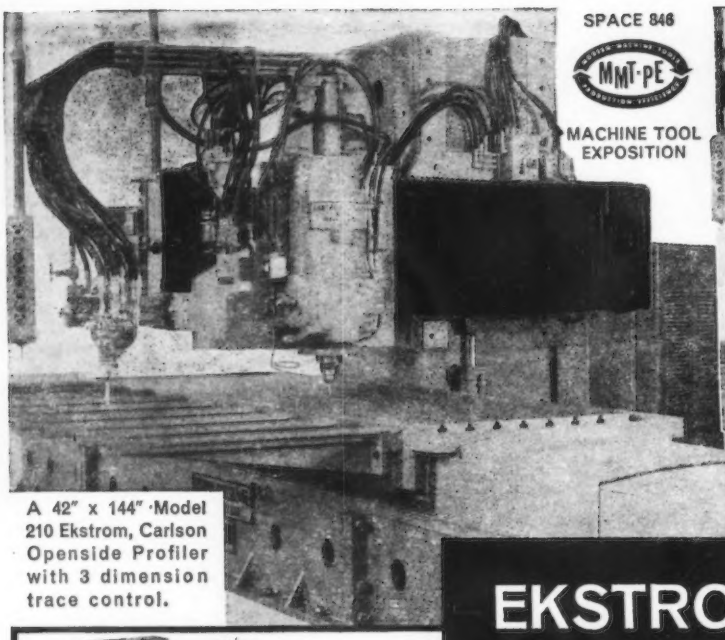
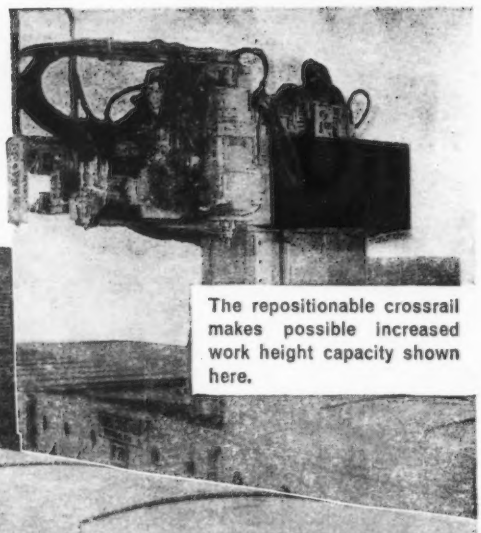
MACHINE TOOL EXPOSITION



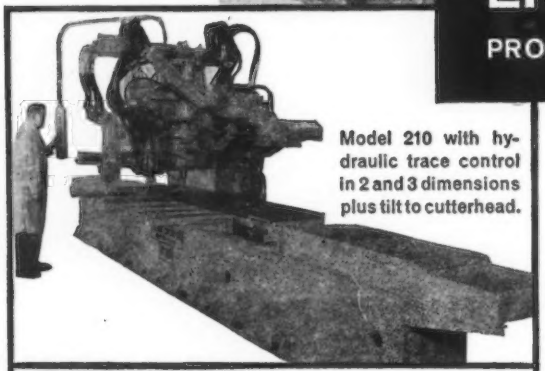
A 42" x 144" Model 210 Ekstrom, Carlson Openside Profiler with 3 dimension trace control.



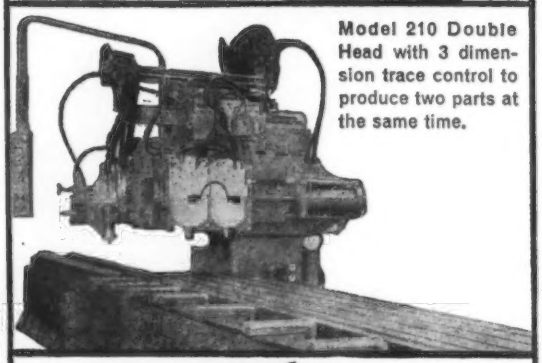
The repositionable crossrail makes possible increased work height capacity shown here.

EKSTROM, CARLSON

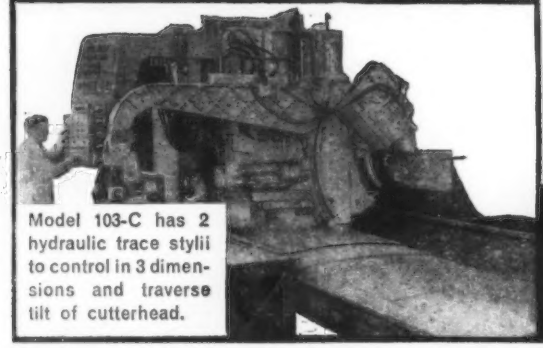
PROFILE AND CONTOUR MILLING MACHINES



Model 210 with hydraulic trace control in 2 and 3 dimensions plus tilt to cutterhead.



Model 210 Double Head with 3 dimension trace control to produce two parts at the same time.



Model 103-C has 2 hydraulic trace stylii to control in 3 dimensions and traverse tilt of cutterhead.

. . . . from small to large

Openside or Bridge Type

Stationary or Traveling Table

Vertical or Horizontal

Single or Multiple Spindles

. . . . with Manual or Automatic Trace and Numerical Tape Control, too!

Yes, whatever your profiling or contouring requirements are there is an EKSTROM, CARLSON Profile Milling Machine (either standard or tailored to suit your special need) that will do your job with utmost efficiency.

Shown here are only a few of our Openside Model 210 Machines and the Model 103-C Traveling Column Horizontal Spindle Machines.

WHY NOT ask for a representative to call and tell you the whole story on these and other EKSTROM, CARLSON high quality Profile Milling Machines.

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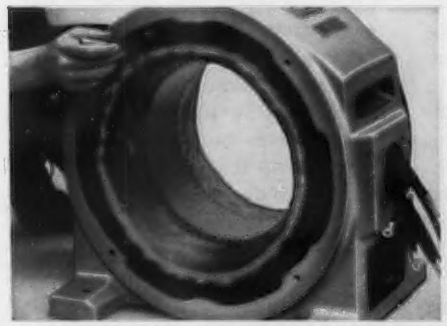
General Electric RTV silicone rubber

New liquid rubber cures without heat, useful from — 70 F to + 600 F, ideal for sealing, electrical insulation and flexible molds.

HEAT RESISTANT SEALING, such as shown on this Douglas DC-8 Jetliner, is made possible with RTV (room temperature vulcanizing) silicone rubber. RTV cures without application of heat; won't shrink (no solvents); forms no voids. It has excellent bond strength, plus resistance to high temperatures, moisture, weathering, ozone, aircraft fuels and solvents.

PRECISION MOLDING of prototype and engineering models and replacement parts is simplified and improved with RTV flexible mold material. G-E RTV's low shrinkage permits close tolerances and fine surface detail.

LOW-COST TOOLING with flexible RTV mold material offers added savings in time and expense. RTV's "built-in" release agent provides easy removal of this epoxy coil-winding form from mold. Total cost reduced 81%, delivery time 90%.



ENCAPSULATION OF STATOR WINDINGS, introduced by General Electric motor departments, extends service life of motors. RTV's resistance to moisture and other contaminants enables these dripproof motors to meet certain applications formerly requiring enclosed units.

POTTING OF AIRBORNE EQUIPMENT provides protection from high altitude arc-over and corona as well as vibration and moisture. RTV silicone rubber protects this cathode ray tube up to 70,000 feet.

RTV COIL IMPREGNATION enables this Hughes Aircraft Co. transformer to provide top performance at 250°. Unlike other insulations tried, G-E RTV compounds proved successful both for coil impregnation and full encapsulation.

For application data and samples of General Electric RTV silicone rubber write Section BB714, General Electric Company, Silicone Products Department, Waterford, New York

GENERAL ELECTRIC

AN **AIRCRAFT & MISSILES** SPECIAL STAFF REPORT

Design Notes on Britain's V.C.10

Vickers-Armstrong foregoes supersonic speeds and concentrates on "airfield performance" in third generation jet airliner

The wing's the thing! In the Vickers-Armstrong V.C.10, latest in the lineage of commercial aircraft, it is the structure of major design interest. Faced with the decision to build its next generation of supersonic aircraft or to improve economy and "airfield performance" of the 600 mph-class jet, Vickers chose the latter route. A clean, high-lift wing was considered a prime requirement.

Continuing a trend set by European designers, the engines on V.C.10 were mounted at the rear of the fuselage. This gave designers clear aerodynamic sledding in seeking the optimum wing for high lift and low drag.

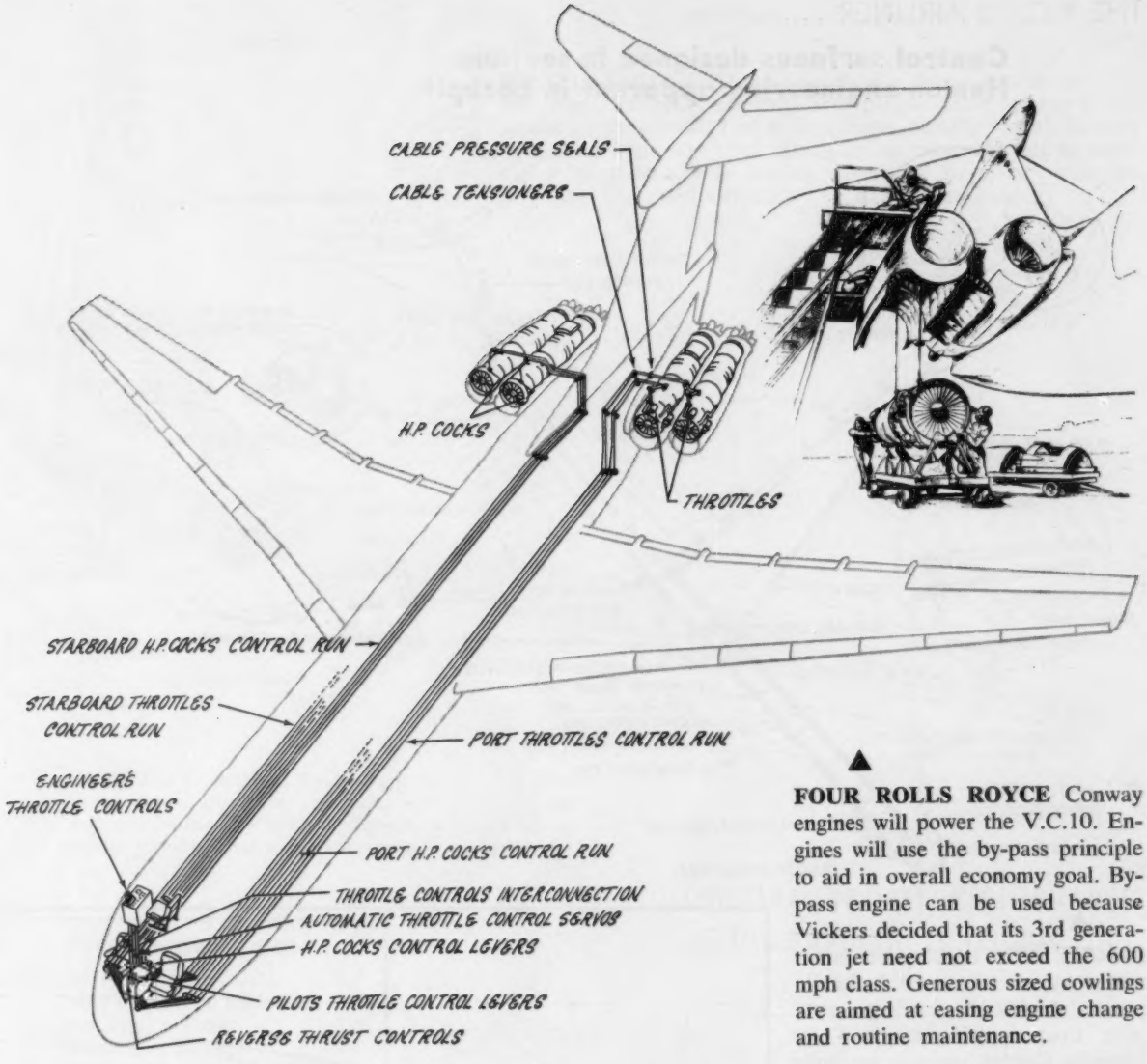
V.C.10 will first fly in the summer of 1961. In service it will carry 150 passengers under the power of four Rolls-Royce Conway engines. By the time the engines ultimately intended for the aircraft are ready, earlier versions will have amassed 2000 flight hours. The concurrency concept is obviously not limited to military vehicles.

There will be no prototype. The first several production models will be put through certification flight trials. This is risky business but is nearly essential in keeping the most modern equipment in airline service. Vickers followed this route in bringing both the Viscount and Vanguard into service. Douglas took a similar course in building the DC-8.

Why Engines In Back? The case for mounting the engines at the rear of the fuselage is a good one. Why U. S. aircraft manufacturers have not yet adopted this course would make interesting discussion.

A wing unencumbered by thick root-end, to accommodate in-wing engines, or by pylons for "hung" engines, gives max performance. It is free to do the job it is primarily intended to do—supply efficient lift. This leads to better take-off and landing performance and increased payloads. Low asymmetric thrust makes handling much easier in the event of engine failure or shutdown. There is little danger of "pod" damage in cross-wind landings. Pavement blast during ground operation is considerably reduced.

There are several structural advantages. Heavy transient loads like those experienced at some pod attachments are avoided. There is no flutter problem, and the stiff wing



▲ **FOUR ROLLS ROYCE** Conway engines will power the V.C.10. Engines will use the by-pass principle to aid in overall economy goal. By-pass engine can be used because Vickers decided that its 3rd generation jet need not exceed the 600 mph class. Generous sized cowlings are aimed at easing engine change and routine maintenance.

structure is better able to prevent onset of control reversal. (A form of control reversal has been listed as a trait in the Boeing 707 in some slow speed flight regimes. This condition has been suggested as a contributing cause in one accident.)

The rear mount also clears jet exhaust from the main fuselage structure and thus reduces noise and the possibility of sonic fatigue.

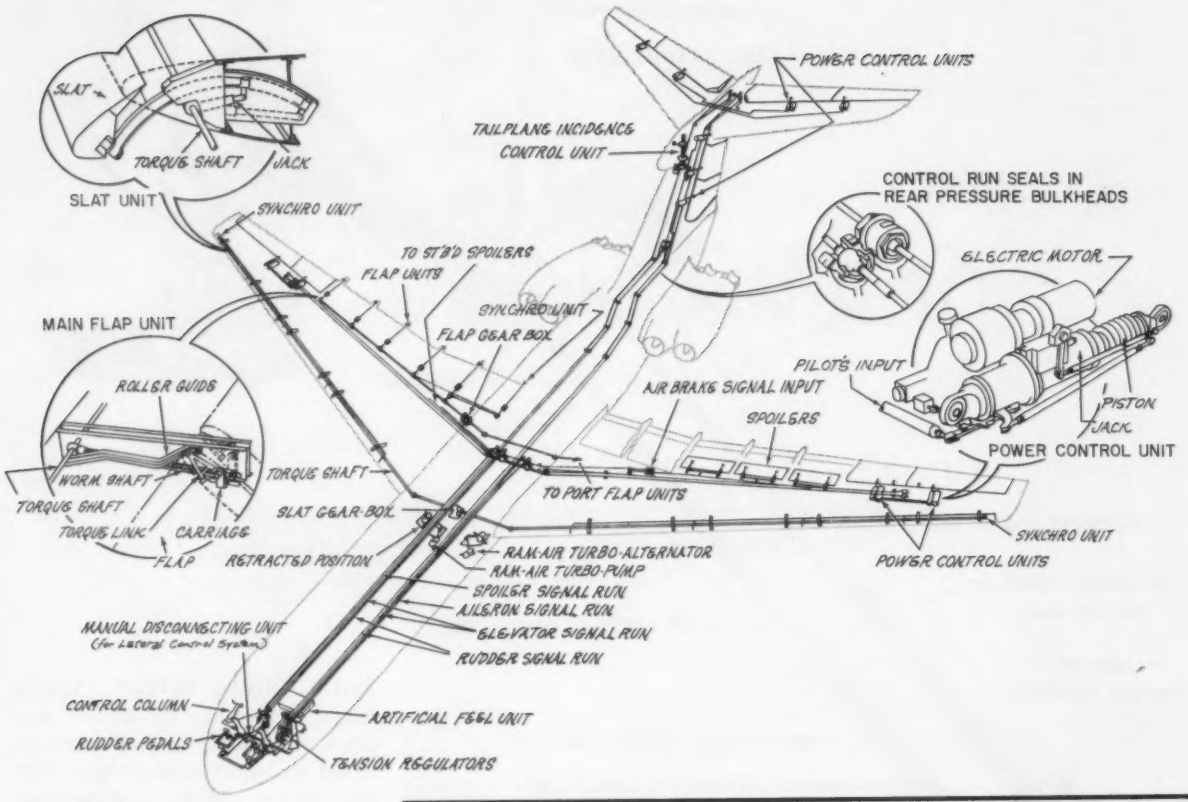
In ground operations there are several safety factors inherent in mounting the engines high at the rear. There is reduced risk of sucking foreign matter into the intakes, and there is decreased danger to ground personnel. During emergency or wheels up landings the risk of tearing loose hot engine parts and fuel lines is minimized.

Fail-safe Systems—Systems in the V.C.10 embody the fail safe concept through judicious "redundancy." This term enjoys wide usage in engineering circles. It is misleading, however, because it implies there is "more than enough" or that something is excessive. This is not the case. Redundancy actually means that multiple systems have been incorporated where the reliability of a single system is not enough to meet safety of flight requirements in the worst foreseeable situation.

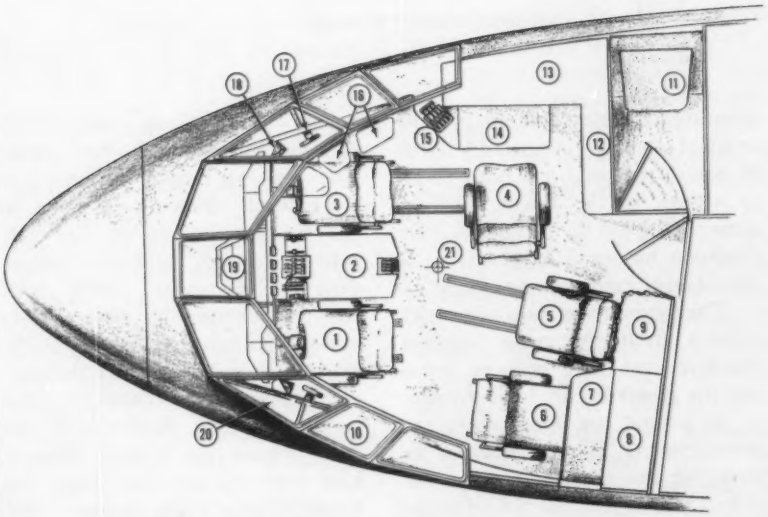
For example, all flight control surfaces are designed in sections. Elevators and ailerons each have four sections. Spoilers on top of the wing have three sections. If an actuator or motor should fail, or "run away" on any one section, there is always sufficient response to overcome the runaway until it is switched out of the system by the pilot. The aircraft can be flown on one elevator section. All control surfaces are supplied power through dual systems. If both should fail, a ram air turbo-alternator and a ram air turbo pump supply emergency power.

continued on next page

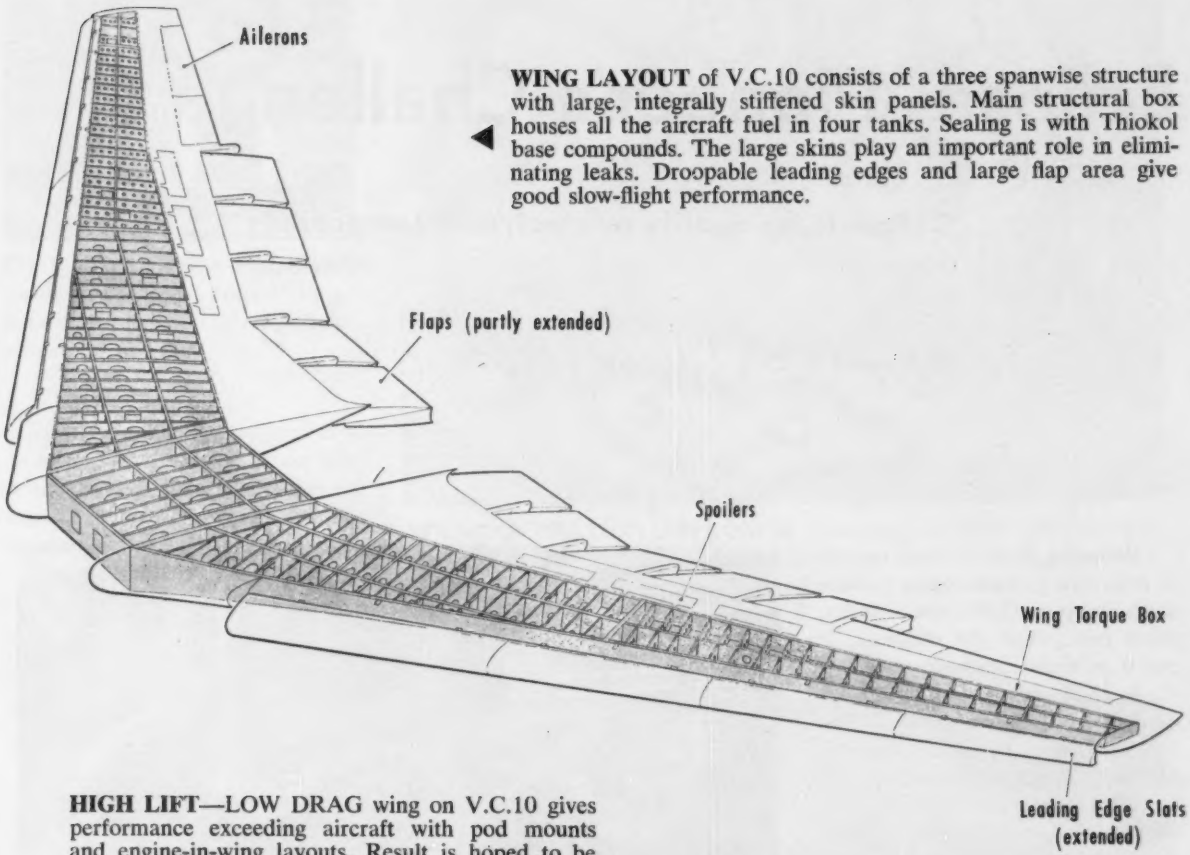
Control surfaces designed in sections; Human engineering apparent in cockpit



▲ **FLIGHT CONTROL** system is actuated by electrical and hydraulic power. "Artificial feel" prevents pilot from applying overload on controls. Control surfaces are built in sections: elevator (four), aileron (four), rudder (three), spoilers (three). Each section is independent of the other and can be cut out of the system without seriously affecting control. Electrical alternators and hydraulic pumps which supply power for the control system are fitted to each engine. Power is distributed through two independent systems. If both these fail emergency power is supplied by a ram-air alternator and a ram-air turbo pump.



FLIGHT DECK design gives special attention to crew comfort. At this stage human-engineering seems to have played an important role.



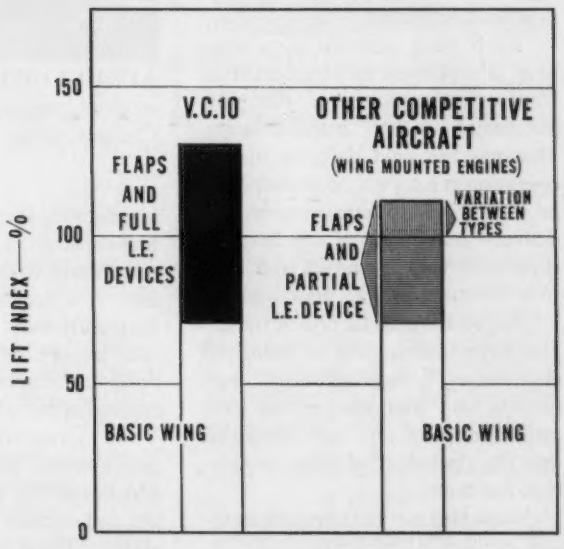
WING LAYOUT of V.C.10 consists of a three spanwise structure with large, integrally stiffened skin panels. Main structural box houses all the aircraft fuel in four tanks. Sealing is with Thiokol base compounds. The large skins play an important role in eliminating leaks. Droopable leading edges and large flap area give good slow-flight performance.

HIGH LIFT—LOW DRAG wing on V.C.10 gives performance exceeding aircraft with pod mounts and engine-in-wing layouts. Result is hoped to be higher payload and more economical operation.

KEY TO FLIGHT DECK

1. 1st Pilot's seat.
2. Pilot's control pedestal.
3. 2nd Pilot's seat.
4. Engineer's seat.
5. Supernumerary's seat.
6. Navigator's seat.
7. Navigator's table.
8. Console and stowages.
9. Wardrobe—teleprinter at base, hats above.
10. Side console (port and starboard).
11. Crew toilet.
12. Electrical distribution panel.
13. Cabin services ducting and Engineer's stowage area.
14. Engineer's table.
15. Engineer's throttles.
16. Eyebrow windows (port and starboard).
17. Nosewheel steering (port and starboard).
18. Cloud warning (port and starboard).
19. Engine fire control panel.
20. D/V emergency window (port and starboard).
21. Sextant position in roof.

COMPARATIVE LIFT PERFORMANCE IN THE LANDING CONFIGURATION



Eclipse–Pioneer's Challenge

Cut costs, up quality on electronic components

By Richard C. Cole, Cost Control Manager
Eclipse-Pioneer Div., The Bendix Corporation

Reducing product costs in face of inflationary trends is like walking down an up-escalator; you must run down faster than the escalator, if you want to reach a lower level.

A challenge of this nature has been accepted for some time, by The Bendix Corp., by organizing coordinated programs directed to lower costs. These programs are conducted on a plant-wide basis at Eclipse-Pioneer, and involve about 1000 active models of equipment.

Concentrated effort on major products such as the air data computer and the vertical scale systems of the F-105, is obtained by organizing the manufacturing force into product-line teams.

Each team, directed by a manager, is supported by members from engineering, inspection, planning, purchasing and manufacturing. Meetings are held daily to discuss operation phases, cost-reduction problems, quality improvement, and delivery scheduled. Each team is supported with a budget and controls for managing its operation.

Support is also furnished by service departments such as industrial engineering, manufacturing engineering and tool design. All cost reduction programs are integrated into the operation of these production-line teams.

Some major cost-reduction methods are highlighted below.

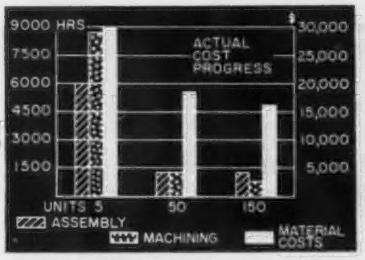
Tool Standardization — Tooling cost is always a major consideration in relatively short production—runs. Standardization has proved the direct avenue to cost reduction in tooling. Practice has been to select a frequently-used category of tool, such as the drill jig, and devise a basic jig adaptable to a large percentage of parts being manufactured.

A series of standard tooling components are thus developed, which can be made in production lots and stocked for immediate availability. These components are used to manufacture special tools and gages, and are stocked in a semi-finished state; finishing operations are completed when the special tool or gage is built.

Results of this standardization have been: a gain in tooling lead-time; reduction in tooling design costs; and a reduction in the cost of making tools of about 30 per cent.

Material Handling—Close tolerances of parts involved in this type of manufacture have required improved material handling methods. A series of containers are injection-molded from linear polyethylene. Containers feature multi-cavity se-

AUDIO-VIDEO SYSTEM synchronizes tape-recorded instructions on assembly sequence with slide projections of component in progressive stages. Compartmented sequence-trays are seen above operator's head.



COST REDUCTION PROGRESS shown in bar-graph reflects the results of manufacturing method improvement program.

quence trays with pre-numbered cavities. As a result, parts are kept clean, protected from damage in transit, and pre-arranged in proper sequence for assembly.

Another measure is helping to reduce damage and facilitate assembly. This consists of incorporating special support structures in containers, to hold odd-shaped delicate sub-assemblies in position for soldering, fastening, etc.

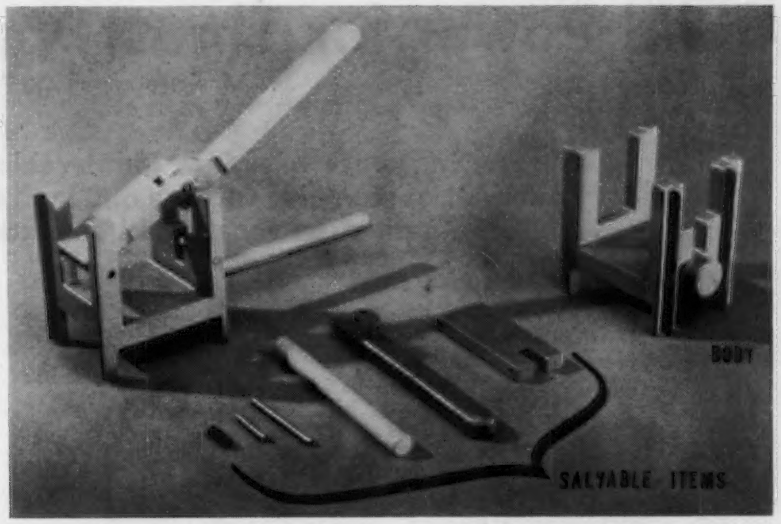
Lastly, packaging engineers have been working closely with the purchasing department to specify the types of containers to be used by sub-contractors. Overall objective in parts handling is to completely eliminate cardboard and wooden packaging of high-precision components.

Method Improvement by Movies—A major portion of direct-labor costs in instrument manufacture results from assembly labor. Motion pictures are helping greatly in the analysis and improvement of adopted assembly methods. Filming and projection of complete operation on a screen allows simultaneous observation by a group, and discussion without interfering with actual production; also re-runs can be made at any phase for detailed analysis.

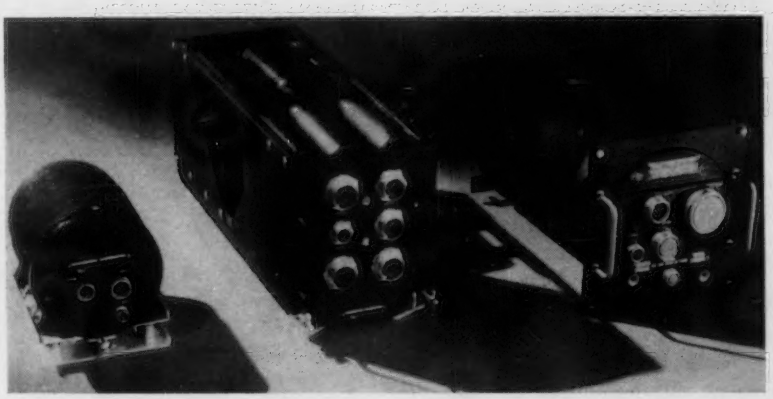
Audio-Video Aides—Operators are taught complicated assembly procedures in a relatively short time through audio-video aides. This system consists of synchronizing tape-recorded verbal instructions with slide projections. Audio instructions reach operator through a miniature ear-phone, so that training does not interfere with rest of operations. In some instances this system has reduced training time by 50 per cent. Additional advantages derived are:

- Fewer lead men are required.
- Training is fully standardized and quality control is simplified.
- Permanent record of procedure allows reference or reuse anytime in future.

Stress on Soldering—Reliability of complete electronic systems often depends on the quality of its many soldered joints. To promote high-quality soldering on a continual basis, both old and new operators attend a soldering school periodically. This practice has paid appreciable dividends in overall improved quality and reliability.



STANDARDIZATION APPROACH to tooling, at Bendix-Pioneer, consists of establishing a versatile base-component adaptable to varying needs. Drill jig with salvable stock parts is typical example.



AIR DATA COMPUTER for the Republic F-105 is one of major systems made by Eclipse-Pioneer. Computer provides air data to automatic flight-control system, fire control, engine control, navigation and bombing, air conditioning, recon and flight instruments.

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Solid Power for Thrust-Vector Steering

AiResearch favors solids for flight-vehicle power systems; Propellant gases drive turbine and hydraulic pump, compressed air used for ground checkout

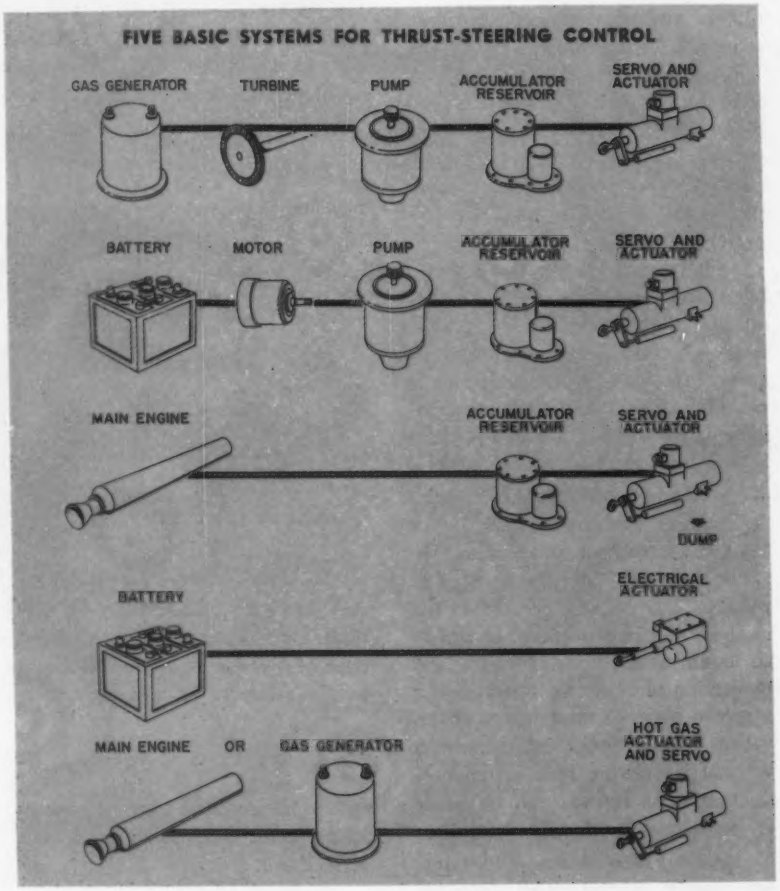
By Richard L. Robinson, Project Engineer,
Missile Systems Group, AiResearch Manufacturing Co.

Use of solid propellants as the primary source of power in a vector-steering thrust system has long been overlooked. Yet, an analysis of the various types of vector steering systems reveals that solid propellants offer many advantages over current systems.

Basically there are five different types of power sources used in thrust vector steering controls; these are presented adjacently in schematic form.

A system, similar to that used on the Minuteman and Polaris missiles uses a battery as its main source of power. Hence, an electric motor driving a hydraulic pump supplies hydraulic pressure to an actuator. This system is easy to check out by simply utilizing the ground source of electric power to test all hydraulic circuitry. However, a battery-powered system weighs considerably more than other systems, in fact, it is at least twice as heavy as solid-propellant system.

Main-engine bleed also may be used as a power source in vector steering. The main engine bleed pressurizes a hydraulic accumulator which supplies power to the acuators. Oil from the accumulator is dumped overboard once it passes through the actuator. This system is simple, with a minimum of moving parts, and as a result quite reliable; however, it is large, also limited in duration and power. There is limited space between nozzles for the vector-steering package.



Also there is no convenient method of checkout for such systems.

Heaviest of all systems are the all-electric. Obviously, all-electric systems offer a convenient checkout procedure but their response time is slow. Because of weight and response considerations, all-electric systems have not been used for vector steering.

Hot-gas servo systems are the most controversial. In these, hot-gas pressure from either the main engine or a separate gas generator is supplied directly to the servo and actuator system. Problems in this

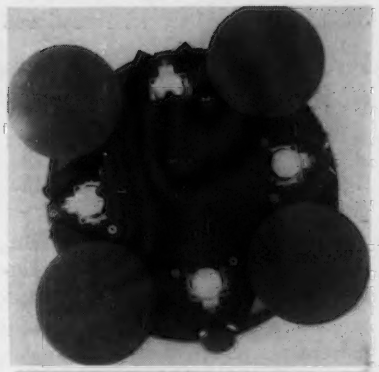
ANALYSIS OF POWER SOURCES FOR VECTOR STEERING CONTROL SYSTEMS

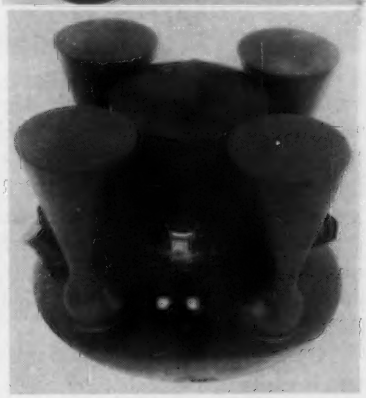
(Based on a minimum 5 hp, 30 sec duration application)

System Attributes	Types of Systems Considered				
	Turbine-Hydraulic	Accumulator-Hydraulic	Electrical-Hydraulic	Hot Gas	Electro-Mechanical
Weight & Volume	1	2	3	1	4
Reliability	1	1	2	2	2
Checkout	2	3	1	2	1
Storage Life	1	1	1	1	1
Growth Potential	1	3	3	2	3
Response Time	1	1	2	2	3
Development Time	2	1	1	3	2
Unit Cost	3	1	2	2	3
Cumulative Ratings	12	13	15	15	19

Numerical ratings (1, 2, 3, 4) represent the relative rank of the systems considered above, in descending order. Most advantageous system is rated "1"; least advantageous is rated "4". In case of ties the systems were rated equally.

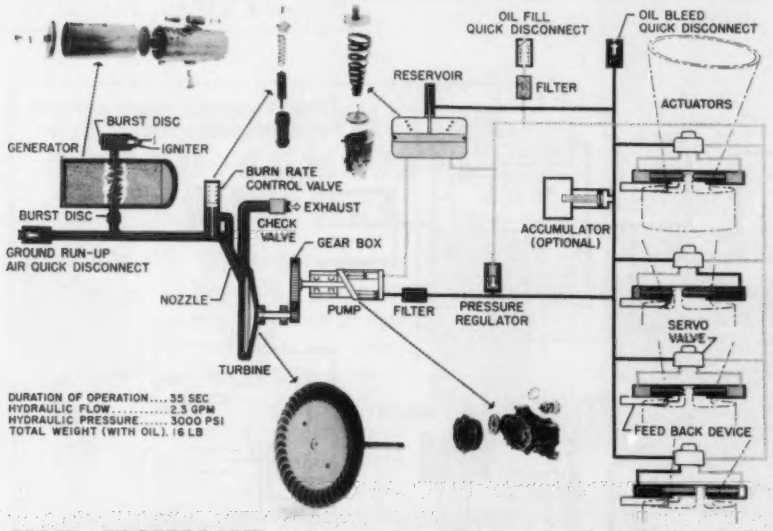
NOTE—This evaluation is not applicable to the Bullpup and Sidewinder category of missiles where small steering loads are involved.



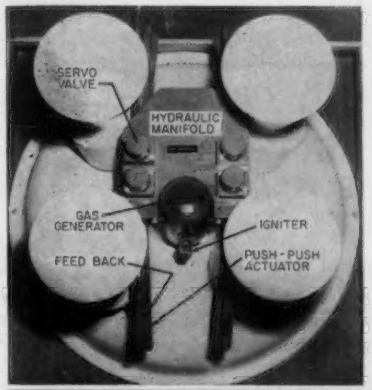


MAIN-ENGINE-BLEED type power source for canted-nozzle vector-steering is shown in mock-up.

SERVICEABILITY of a typical solid-propellant vector-steering system is evident on mock-up; can be removed.



SOLID - PROPELLANT vector-steering system is activated electrically through an igniter which starts the grain burning in both directions from the center.



case, are the filtering and supplying relatively clean hot-gas to the servo system, and designing valves compatible with the hot gases. Hot-gas servo systems appear quite feasible using a separate gas generator, but considerable development is necessary to attain reliability comparable to that of other systems. Generally, reaction time of hot-gas servo systems (10 CPS) is considerably longer than the reaction time for hydraulic systems (55 CPS).

A schematic diagram is shown of a solid-propellant vector-steering system, activated by an electrical

Firing gas generator ahead of missile booster acts as checking means for generator operation

signal to the igniter which fires the grain.

In this instance, the propellant grain burns in both directions from the center; hot gas then operates the turbine which drives a fixed-displacement pump through a gear box. A burn-rate control valve keeps the turbine inlet pressure at a constant value to compensate for variations in grain burning-rate due to ambient temperature variations. Remainder of circuit is standard hydraulic components comprising a hydraulic servo system. Nozzles shown in the schematic are of the canted type, but system is easily adaptable to both pivot nozzles or jetavators.

Ground checkout of such a system is easily accomplished by coupling a suitable compressed air source to the quick-disconnect provided for this purpose. This permits complete checkout of turbine drive and hydraulic system, leaving the gas generator as the only unchecked item in the system. Firing the gas generator a few seconds ahead of the missile booster, determines that the unit is functioning properly, before the actual missile firing.

One apparent disadvantage to this system is the pneumatic ground checkout. In some instances, the logistics of supplying electrical power seems more feasible than supplying compressed air power. Granted, there are some applications where this objection is valid. However, the overall benefits in a solid-propellant vector-steering system require a review of this logistic situation in current and future applications.

It is interesting to compare this system with the pressurized accumulator system shown earlier. Here approximately twice the hp-seconds is supplied for less than one-half the weight of the earlier system.

A solid propellant unit currently being built by AiResearch supplies both electrical power and terminal guidance. This unit supplies power through a turbine-drive package. Several types of electrical power are supplied through a regulated electrical supply package. The hydraulic pump supplies the hydraulic servo circuit for moving the steering surfaces. Essentially, this system is one step more complicated than the vector-steering unit just discussed. If the alternator and corresponding electrical circuitry are removed, this system is the same as the vector-steering unit.

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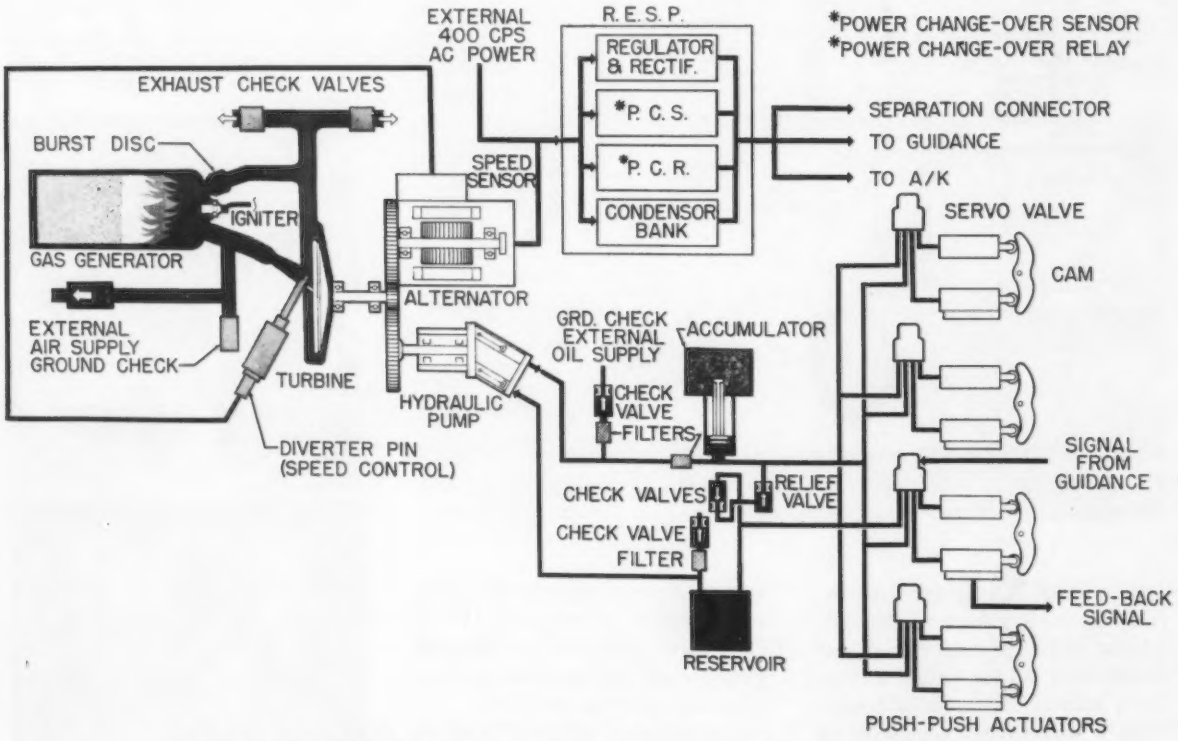

ADVANCED SYSTEM being built by AiResearch uses solid-propellant gas generator to supply both electrical power and terminal guidance.

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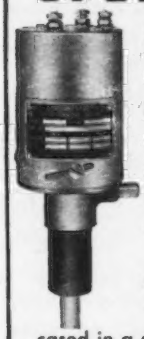

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Relentless Bugaboo—Corrosion

Chromate conversion coatings prove versatile weapon in combating aerospace environment's attack on materials

By John P. Kushnerick

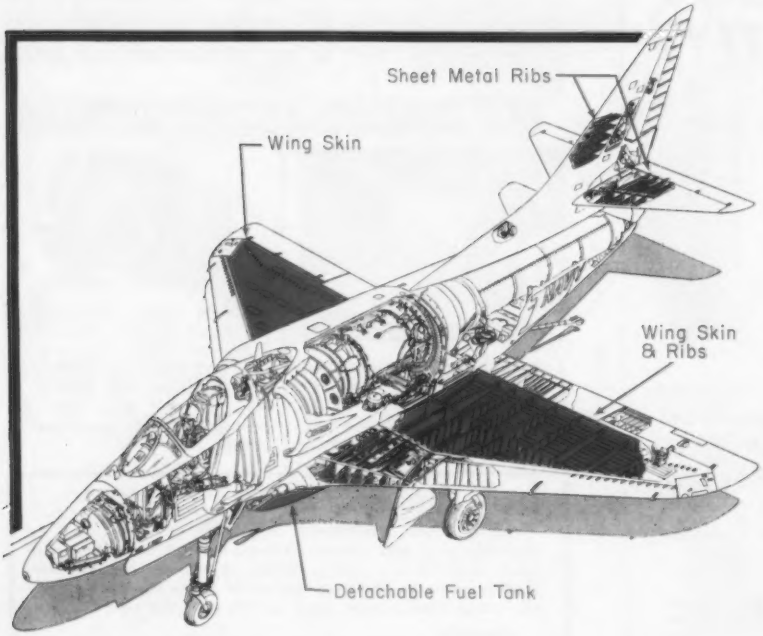
Nature is constantly at work undoing man's handiwork. Even the most exotic of his creations has no way of replenishing itself. Few have even the ability to protect themselves. The tattoo of nature's invisible invaders from the air and sea around us takes a rapid toll in some cases, a slower toll in others. But, the determination to reduce man's greatest engineering marvels never ceases. In some cases it is manifested as simple oxidation, in others more sophisticated forms of corrosion do the dirty work.

The challenge of guarding against this deterioration is obviously no small task—especially when the product is as vital, complex, and glamorous as an aircraft or missile. These vehicles wait in readiness, fly through, and create, environments where nature's agents can show their strongest hand. Many different approaches have been tried. A study of them all is a study of a complete science and a complete industry.

Chromate Conversion—One of the more successful approaches is the use of chromate conversion coatings which provide a gel-like surface film by chemical reaction between the metal being treated and the processing solution. They are entirely different from films which are electro-deposited, and have certain specialized advantages:

- Require less expensive equipment.
- Require less specialized labor.
- Become integral with metal, rather than remain as superimposed coating.
- Provide electro - conductive surface, important in some subsequent joining techniques.
- Allow spot repairs to be effected on damaged or inadequate surfaces.

The coatings are widely accepted in the aerospace industries and are used under MIL-C-5541. They can be applied to aluminum, magnesium, zinc, cadmium, and cuprous alloys. Immersion times in the treating solution vary from a few seconds to about 4 min.



CHROMATE CONVERSION coatings are used at Douglas to protect many sections of A4D (shown) and A3D against corrosion of sea atmosphere. Both aircraft are operated from aircraft carriers.

For Electronics—Hughes Aircraft Co. uses a chromate conversion coating known as Iridite 14-2 on painted and unpainted electronic equipment. Aluminum alloys 6061, 7075, and 2024 are the materials treated.

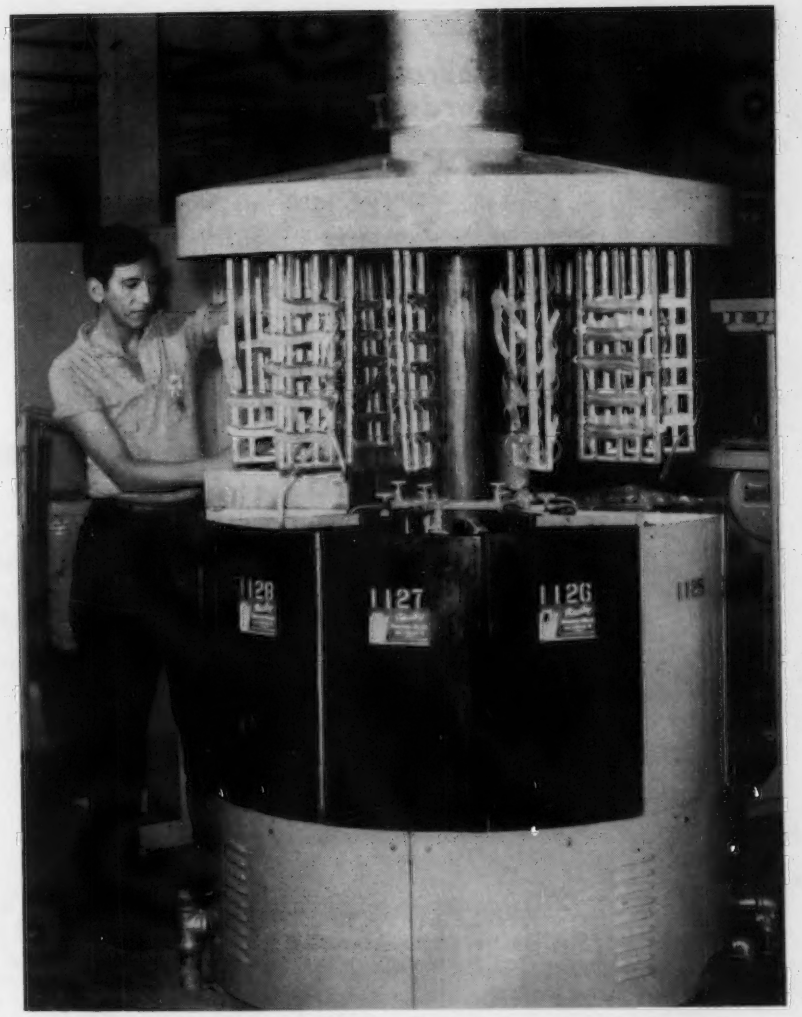
Reasons that moved Hughes to switch to a chromate conversion coating from an anodic coating are: (1) Electroconductivity, the oxide coating on anodic deposits made electrical connections a problem; (2) Processing costs, expansion and maintenance of anodic facilities was judged costly; (3) Time saving, areas that were to receive electrical contacts were marked to prevent anodic deposit; (4) Equipment performance, uneven oxide coatings were felt to contribute to radio noise in some applications.

Hughes uses an automatic machine in applying the coating. Parts to be processed are degreased then hung on a monorail. They are conveyed through an alkaline cleaning cycle, two rinses, and a 2¾ to 3 min immersion in the chromate solution. Three rinses in running water, and a hot air drying cycle complete the operation.

Main quality control on the solution is a pH check twice daily for a 1.5 to 2.0 level, and a titration check for hexavalent chromium at the same frequency.

For Carrier Planes—At Douglas-El Segundo, where carrier based A3D and F4D are turned out, three treating lines are in use for applying chromate conversion coatings (Iridite 14) to wing skins, and detachable fuel-tank sections. Materials of construction are 6061, 2014, and 7075 aluminum alloys. The kind of corrosion guarded against is that typical of an ocean atmosphere. Paint is applied over the coating.

In addition to the three lines for large parts, Douglas has two "merry-go-round" machines for treating small parts like sheetmetal ribs. Each machine is a continuous processing unit made of triangular tanks mounted in a circle. Cycling is automatic and effects complete treatment of the parts from precleaning to priming with paint. Controls are largely by time immersion. A coating is considered satisfactory when a golden iridescence is obtained. The usual periodic checks are done on test panels and solutions in accordance with MIL-C-5541.



MERRY-GO-ROUND puts small parts through automatic corrosion protection cycle at Douglas. Coating used gives yellow color to metal and affords instant visual check. MIL-C-5541 tests also apply.

For Ballistic Missiles—Convair-Astronautics may be said to represent a typical user of the chromate conversion coatings on aluminum parts for missile components. A coating known commercially as Iridite 14-2 is being used for surface treatment of alloys 2024, 7075, 6061 and 5056. The parts are for Atlas and are up to 10-ft long.

Convair's Manufacturing Process Specification (MPS71.12B) calls for this treatment:

(1) Vapor degrease at 180 to 190°F, as time requires.

(2) Alkaline clean in a solution of Oakite 61-A at a concentration of 4 to 8 oz/gal at temperature of 170 to 190°F, as time requires.

(3) Rinse in tap water at 170 to 190°F, 5 to 10 min.

(4) Deoxidize in a 10 to 12 oz/gal solution of Oakite 34 at room temperature, 3 to 10 min.

(5) Rinse in tap water at room temperature, 5 to 10 min.

(6) Immerse in Iridite 14-2 at a concentration of 1 to 1.8 oz/gal

How Convair uses chromate conversion coatings to protect Atlas hardware

at room temperature, 1 to 4 min.

(7) Rinse in running tap water at room temperature, 3 to 5 min.

(8) Hot air dry at 150 to 190°F, as time requires.

Convair also uses the brush-on method of refinishing local damaged areas on finished parts, and the MPS sets forth the following procedure for this:

(1) Clean areas to be refinished by brushing with TEC 91 or Toleuene. Wipe off with clean cheese cloth.

(2) Apply Deoxidine cleaner for 5 min on area to be refinished.

ELECTRIC PARTS at Hughes receive corrosion resistant coating. Hughes switched from anodic coatings to chromate conversion coatings on some parts. For details read full text.

CONVAIR ASTRONAUTICS has an eight-tank line for chromate conversion coatings. Parts up to 10-ft long can be accommodated. But, small hardware constitutes the bulk of Atlas work.

(3) Rinse off Deoxidine with a stream of tap water.

(4) While surface is still wet, apply Iridite 14-2 with a brush for 15 min. Extend applications area slightly beyond Deoxidine-cleaned areas, and keep area covered with chromate solution at all times.

(5) Rinse with tap water.

(6) Dry in air.

The manufacturing process specification notes that the treated parts will vary in color, depending upon the alloy being treated, but that the variation need not be cause for rejection. Where the clear chromate conversion coatings are applied, as opposed to the golden iridescent coatings, a solution known as ARP No. 70 (Spot Test Solution) is used to detect the existence of the clear coatings. When this chemical is applied to a clear coating, a green spot appears.

Desirable Properties—The properties of the chromate conversion coatings that are most desirable to this manufacturer are corrosion protection in accordance with specification MIL-C-5541, an electrically conductive film, a base for paint, and trouble-free processing and long life.

Exhaustive tests were made by Convair prior to the installation of the chromate conversion system. These included a 10 month outdoor exposure test, normal salt spray and humidity test, galvanic couple tests with dissimilar metals and the determination of the amount and intensity of corrosion due to the alloying agent of the aluminum. Other tests were for paint adhesion and electrical conductivity.

Corrosion encountered by the parts being treated includes exposure to salt air, alkaline and acidic soil as well as extreme variations in heat and cold.

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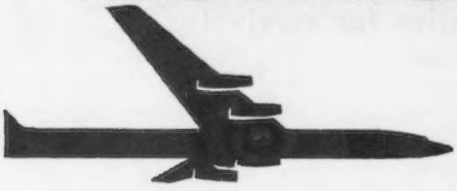
Vāp-Air electro-pneumatic air temperature control system



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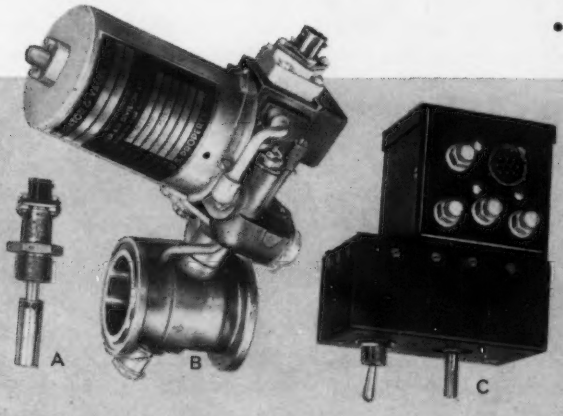

A **Duct Temperature Sensor.** Resistance type, only 3¾" long. One of many types made by Vapor, including thermistors, wire-wound resistance-temperature pick-ups, mercury contact thermostats and the new Vāp-Air MERCISTOR.

B **Valve and Actuator.** Two types, ON-OFF or full-modulating variable opening. Considerably lighter and smaller than electric valves, lighter than other pneumatics.

C **Controller.** Automatic Magnetic Amplifier Power Controller acts as temperature control, power converter and transformer.

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Biomechanics of Weightlessness

Building of stations and vehicles in outer space requires work without help from gravity or natural traction;

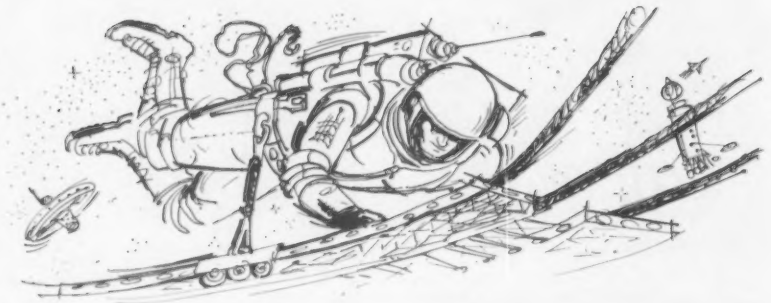
"Open-Force" systems will produce weird and dangerous effects; Re-orientation of man's working habits imperative for survival

By H. T. E. Hertzberg
Anthropology Section, Aero Medical Lab., WADD

A number of recent proposals suggest the in-space assembly of orbiting platforms, with parts from the Earth*. Such projects imply that a certain extent of hand labor will take place in outer space.

Protected by a capsule, a man can probably continue to exist in this environment, but he must also be able to do manual work outside his capsule. Hence, fabrication of stations in space depends first on the development of a suit in which man can live and work, for several hours at a time before he has to return to his capsule. Yet even when he has a suit, certain aspects of the space environment will govern his ability to work.

First, there is no gravity, hence there is no traction. Therefore, all methods of exerting muscle force depending on traction must be ruled out. This means, for example, that in outer space, conventional riveting, where one man with a rivet gun exerts forces which are opposed by another man, would be impossible. Without traction, neither man could oppose the other, and the rivet-gun forces would drive them away from their work. From this mundane example, it is clear that the biomechanics of weightlessness must be carefully considered in planning work in outer space. Second, the



human body on earth is a prime mover that can exert forces in two ways: one limb may exert force directly on other limbs, forming a "closed" force system; or the limb may direct its force upon other objects external to the body, thus constituting an "open" system.

In a closed system, fingers may grip a ball, hands may push against

each other, or pull on opposite ends of a shaft. In an open system, the hand may hammer a nail, or a man may buck a rivet by leaning against it. In all open systems, either directly or remotely, the earth is a part of the force diagram, and traction due to gravity is the usual means whereby the earth is used. Man's body with its whole method of locomotion has evolved according to this fact, and we are conditioned to gravity and traction from birth. When we now place this organism in an environment that lacks gravity and traction, we are severely hampering its effectiveness. This is because so large a part of man's conventional force output depends on gravity. (We may neglect here the fact that an appreciable part of the alimentary processes—e.g., act of drinking—on which man's energy depends, also makes use of gravity.) Hence it is clear that some substi-

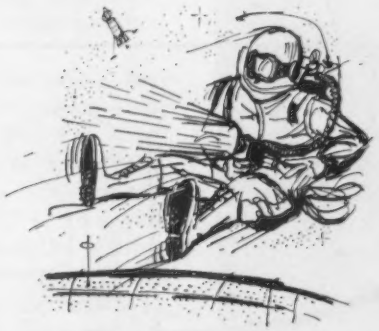
tute for traction must be developed so as to create closed-force systems in space to substitute for the numerous open systems that we habitually use on Earth.

It seems rather likely that the muscle force that a pressure-suited man can apply in closed systems in space will not be severely reduced from what he can exert on earth. Of course, there will be an appreciable decrement due to the sheer restrictiveness of a pressure suit, the internal friction of the garment layers, the tendency of the inflated suit to assume and maintain a globular form, and the slippage and clumsiness that inevitably accompany the use of heavy gloves. This decrement however should not be so large that the man's closed-system strength is reduced to only a small fraction of its normal value. There is reason to hope that the decrement may not exceed about 50 per cent.

In an open system, the force capability would be reduced nearly to zero. As Gauer and Haber** have pointed out, a weightless man exerting torque on a shaft will tend to rotate himself about the axis of the shaft. Thus open-force systems must be avoided, and all manual work to be performed in space must be planned in minute detail for the conditions to be encountered. Potential methods for the fastening of sub-assemblies in space may include: squeeze-riveting, explosive-riveting, blind-riveting, or similar closed-force systems. To exert force on a surface, the man could hold himself to it through a harness on his body, attachable to the surface. If the surface were narrow enough, he could grip the edges with rollers at the ends of the straps, thereby enabling him to crawl or walk the length of the surface; otherwise lugs or slots or other means of attachment might well be used with quick-release mechanisms for the same purpose. Magnetized shoes and gloves are also possible.

In addition, the number of tools required must be at a minimum, and these must be tied to him, for he will have nowhere to lay them down.

Another problem for this worker will be to get from one point in space to another. Perhaps the simplest means will involve a source of thrust such as a compressed-air bottle tied to his person, with a flexible hose and nozzle to be held in his hand. To displace himself he exerts thrust in the direction opposite to where he wants to go, and to stop he exerts thrust in the same direction. Chief considerations here are the acceleration he can achieve with his thrust, the duration of his fuel, and the mass of the equipment.



This last information will be necessary because the worker will need a fairly close idea of the location of his center of gravity. Although his equipment will not weigh on him, it will still possess mass, and unless he exerts his thrust radially to the center of gravity of his body plus his equipment, he will spin himself around in space. In attempting to stop this spin, he could easily worsen his situation. Thus arise the possibilities for disorientation—even death, if the rate of spin is too high. Because there is an infinite number of directions in which a man may have to exert thrust in 3-dimensional travel, under many conditions of body loading, a hand-held nozzle method may probably be the most easily mastered. Mechanical methods tend to be heavy, complex, and to lack human flexibility.

It also seems likely that space-tugs of various types will be necessary to tow loads heavier than those the man's personal thrust can properly accelerate. There will have to be simple ways of permitting men to couple these loads and to uncouple them after delivery, and techniques of stopping them after they have been started. The additional complications of orbital speeds appear to pose formidable problems in propulsion.

To obtain some approximation of the forces men can exert in various g-fields from about plus 2 to minus 2, the Anthropology Section of WADD is designing and fabricating equipment for both closed and open system tests. Dynamometers for hands, and arm levers to be pushed and pulled while the subject stands or sits, are being prepared for installation in an airplane that can attain zero g for appreciable length of time. Tests are planned on subjects wearing a variety of protective clothing. Over a period of time the strength decrement for each condition and each garment can be ascertained; the strength decrement due to high positive g forces are also being studied.

◆

* *For example, Stuhlinger, E., "Outlook to Space Travel," Scientific Monthly, December 1957, V. 87.*

** *Gauer, O., and Haber, H., "Man in Gravity-free Conditions," German Aviation Medicine in WW II, Vol 1, 1950.*

This article is a slightly-condensed version of a memorandum by the author, widely circulated through the Aerospace Medical Laboratory. Mr. Hertzberg's original studies on the subject were presented in 1958.

High-Frequency Resistance Welding

Designers can specify and expect quality in complicated welded shapes using this often overlooked technique

High-frequency resistance welding brings to seam welding many of the advantages which spot and impulse welding offer for joining specific points. With proper techniques, quality welds can be achieved at speeds exceeding the arc methods.

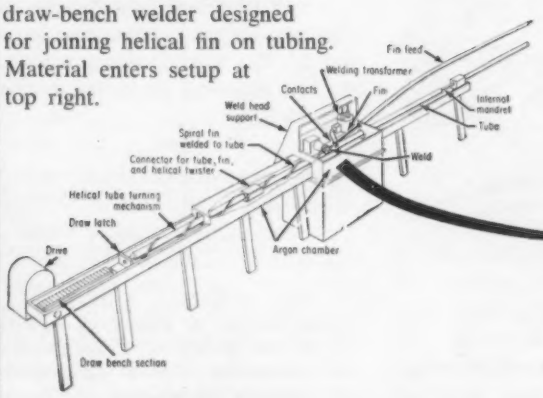
Main differences between existing resistance welding techniques and the new method are: the current reverses at a much higher rate, (450,000 cps from a line current of 60 cps); current does not follow the direct low-resistance path between the two electrical contacts, rather it follows the long, low-inductance path.

One method, known as the Thermatool welding technique, allows the use of the same welding head to continuously join metals from the 0.004 in. to 3/8 in. thickness at speeds up to 1000 ft/min. Metals being joined include zirconium and titanium.

The Secret—"V" Seam

The edges of the metal to be joined are positioned opposite each other as the strip metal travels through a forming mill. A major differ-

FIG. 1. DIAGRAM SHOWS draw-bench welder designed for joining helical fin on tubing. Material enters setup at top right.



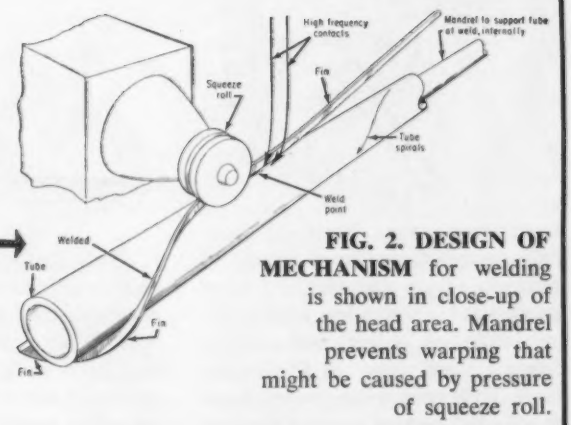
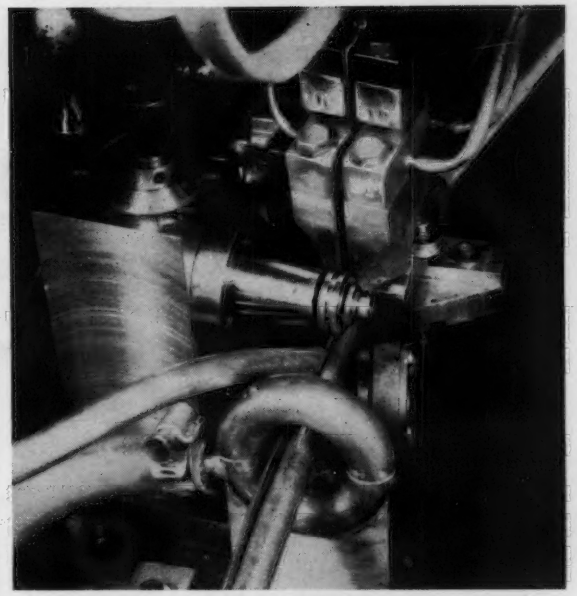


FIG. 2. DESIGN OF MECHANISM for welding is shown in close-up of the head area. Mandrel prevents warping that might be caused by pressure of squeeze roll.

ACTUAL SPIRAL WELD shows fin and tube passing through "donut" which injects argon into weld area. Squeeze roll, behind "donut," effects the weld. Material is zircalloy.



ence between low-frequency resistance welding and this newer method, is that the open seam is kept in an elongated "V" as it moves into the welding head. The root of the "V" is at the squeeze rolls which effect the weld. The high frequency current is introduced into the metal by means of two sliding contacts. These ride one on each side of the open seam about 1 or 2 in. from the root of the "V." Each side of the "V" is a return conductor for the other, since the tendency of current flowing in the low inductance path is to flow on the two surfaces of the material facing each other. These are the surfaces being welded. Due to the "narcissism" of high frequency current, it hugs the opposite edges of the metal. This skin effect produces localized high intensity heating so the edges at the root of the "V" reach welding temperature. Pressure applied at the root of the "V" results in a forged weld—lap, mashed lap, or butt-edge, as desired. This method permits tubing or strips of ferrous or non-ferrous metal to be welded at very high speeds. It also makes possible the welding of strip to tube, and innumerable odd combinations.

Welding A Helical Fin

An interesting application of this process is in welding of a spiral zircalloy fin to a zircalloy tube. Because the tube must rotate to permit the fin to be welded helically, the operation cannot be a continuous process. It must be accomplished on a draw bench in finite length. Fig. 1 shows a draw bench and welder designed for the production of spirally finned tubing.

In this particular operation the tube is fed into the draw bench over a mandrel which supports the tube and prevents distortion. The strip of metal to be welded to the tube is introduced through a fin feed, and the tube and fin are brought together as an elongated "V" in an argon chamber. Within the chamber one of the sliding contacts rides on the tube and the other on the fin to introduce the high frequency current that causes the metal to heat to welding temperature.

✦

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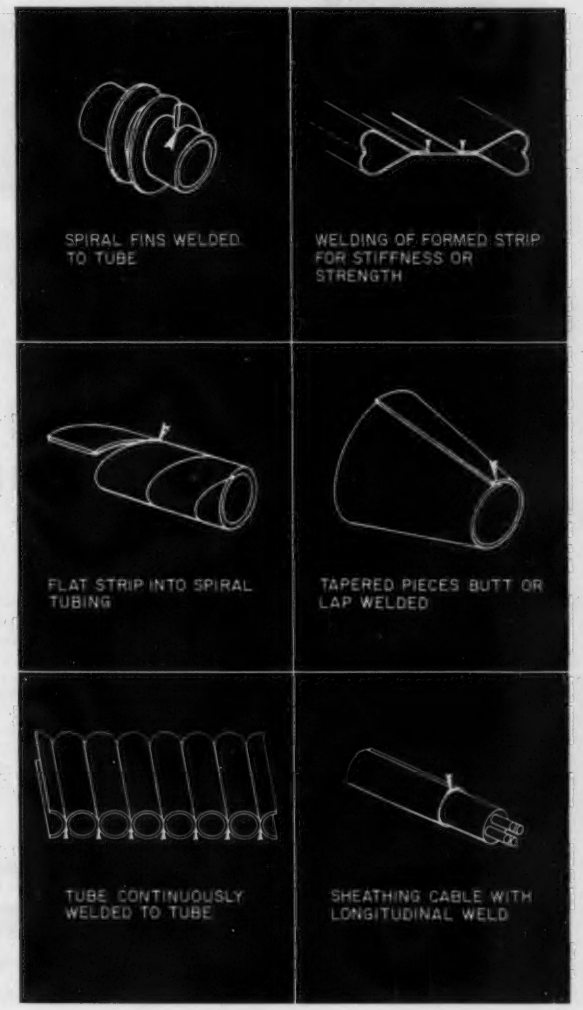
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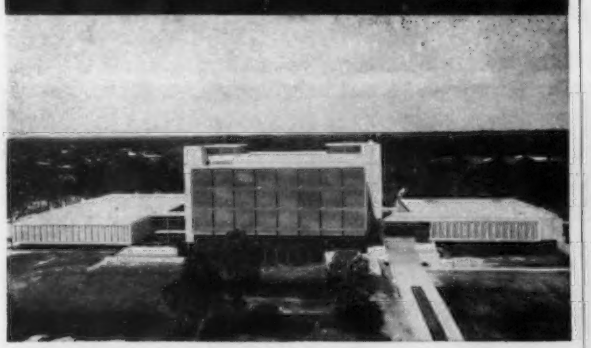

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Arc-Jet "Push" For Satellites

Electric propulsion system evolves from reentry studies at Avco; Prototype runs give 0.75 lb thrust for 47 hr.

By Peter Sigmund

The ability to build and launch scientific satellites has been demonstrated. The ability to keep them in orbit as long as we would like has not. Nor, has the ability to change the orbit, or the position of the satellite in its orbit been adequately demonstrated. We need a "steering system" if communications satellites, and spy-in-the-sky vehicles are to realize full potentional. To have a steering system we need a power source, one of long duration.

Arc-Jet Engine—Avco Research & Advanced Development has demonstrated an "electric propulsion" device which will serve as a prototype in its satellite steering program. The power source is called an arc-jet engine. It weighs 3.5 lb (exclusive of electrical generator), uses helium as a working fluid, and has been run for 47 hr in vacuum.

The arc jet is one of the simplest proposals for electric propulsion. The working fluid is injected into the arc chamber, heated by Joule heating as it passes through the discharge, and is expanded through a conventional rocket nozzle. The convergent—divergent nozzle converts the ohmic heating in the electric arc discharge into directed kinetic energy.

The Avco model produced about ¾ lb of thrust at a specific impulse of 1000 sec. Power input was 30 kilowatts. The total velocity increase that could be imparted to a 1000 lb satellite with this system is calculated to be 4000 ft/sec. Tests were conducted in a vacuum chamber with a simulated altitude of 95,000 ft. Viewing ports in the chamber allowed constant observation during the 47-hr run.

Outgrowth of Reentry — The scaled-down arc jet is an outgrowth of a program aimed at simulation of reentry temperatures. It is a modified version of a flame-spray unit for coating metals and ceramics where 12,000°F flame temperatures are required.

One of the aims of current tests is to study electrode erosion and cooling of the nozzle in long-duration runs. Reliability of component and further simplicity of the system are the primary goals.

This engine uses a tungsten-composite cathode, and liquid-cooled copper anode. Hydrogen as well as helium has been used as a working fluid.

Complete Avco system will consist of the thrust device, an electric power supply (solar cells or nuclear source) and a tank of liquid helium. Although engine weight is about 3.5 lb, as much as 1000 lb of fuel and power supply may be needed to support it.

◆

HOT FLAME of arc-jet engine for satellite propulsion undergoes checkout at Avco. Nozzle is not in place. Unit gives 1000 sec Isp.

New Materials

New Cladding Process

New cladding process for the manufacture of laminated precious metals, base metals and refractory metals enables wrought metals to be bonded together in the solid state without the use of a bonding agent at the interfaces.

Products made with this process are superior with regard to dimensional requirements, purity of the metals, and oxide free interfaces. The result is increased production yield of semi-conductor devices.—Composite Industrial Metals, Inc.

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Four new elastomer - phenolic, thermosetting, dry bonding, film adhesives far exceed military specification MIL-A-5090B. Designated Scotch-Weld AF-10, AF-30, AF-31 and AF-32, they provide uniform adhesive thickness throughout the joint, controlled confinement of adhesive to the immediate bonding area, clean bonding operations and simple application procedures. Shear strengths range from 3040 psi to 4180 psi. Peel strengths range from 55 to 110 lb per in. of width at 75°F.—Minnesota Mining and Mfg. Co.

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Hi-Strength Plastic

High-strength, glass-fiber reinforced plastic has a unidirectional flexural strength of 250,000 psi. Initial flat sheet laminates have gone to several major manufacturers for their own evaluation and verification of the high strength properties. Material has good dielectric strength, is readily adaptable to secondary bonding, has high wet strength retention, and can be drilled, turned on a lathe, milled and threaded, and can be colored, according to the company.—Parallite Mfg. Co.

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Coating for Electronics

A silicone base varnish has been developed as a protective coating for electronic components. Called Melvar A-100 it reduces moisture absorption and acts as an insulator. The varnish is particularly well suited for protectively coating transformers, coils, capacitors, resistors, and printed circuit boards. It has a low curing temperature, high operating temperature, and good fungicidal properties. — Melpar, Inc., Special Products Dept.

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Improved Propellants

Improved methods have been devised for producing three new nitrogen-fluorine compounds, dinitrogen tetrafluoride, dinitrogen difluoride and difluoramine. The yield of nitrogen trifluoride has also been increased. Nitrogen-fluorine compounds can give liquid and solid propellants greater specific impulse than propellants currently being used. — Thiokol Chemical Corp.

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Carbon to Steel-Direct

A new process allows carbon to be coated onto steel. Used as an electron tube anode, the material will have high emissivity and power dissipation with low gas content. Density is twice that of gas carbonized steel.—Texas Instruments

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Glass for Electronics

Two new glasses are designed for use as the dielectric material in electroluminescent devices. Supplied as a 400 mesh powder or frit, glasses are used as a phosphor-containing medium. They were formulated to provide chemical compatibility with EL phosphors and to match thermal expansion values of glass and ceramic substrates.—Corning Glass Works

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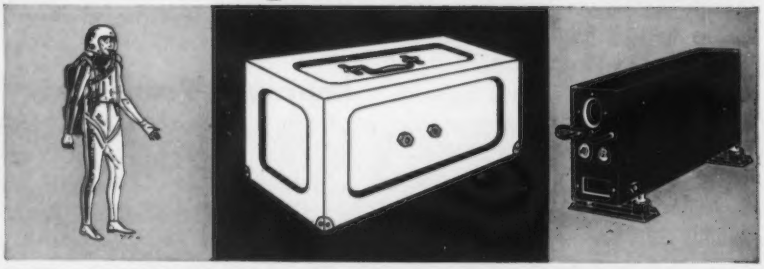

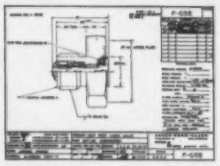

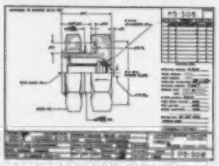

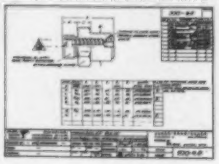

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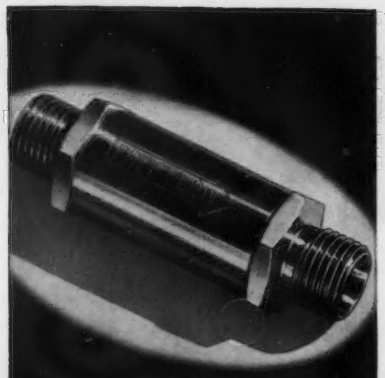

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PRECISION
CONTROLS

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quality, engineering, workmanship

Kohler Precision Controls include a wide range of valves, fittings and parts in various types and sizes for industrial equipment, automotive, aircraft and missile applications. Complete facilities in one plant, with unified supervision, contribute to maximum control in manufacture, prompt deliveries. Ultra-sonic cleaning facilities. Air filtered to 10 microns in area where hydraulic system components are assembled, tested and packaged.

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JET ENGINE PARTS
AIR VALVES
NEEDLE VALVES
ENGINE PRIMERS
PLUG VALVES

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Circle 39 on Inquiry Card

New Books

ENCYCLOPEDIC DICTIONARY OF ELECTRONICS AND NUCLEAR ENGINEERING. By Robert J. Sarbacher. Prentice-Hall, 1959, 1417 pp., $35. An exhaustive reference work embodying definitions approved by official technical societies. About 14,000 entries and 1400 illustrations are included together with an equally-extensive scale of cross-references. The author has endeavored to broaden the usefulness of this volume by including terms of elemental electric and magnetic theory and atomic physics, as well as definitions from the broader principles of physics. Students, technicians, scientists, and technical writers involved in the subject fields will find this masterful work highly useful.

HIGH TEMPERATURE MATERIALS. Edited by R. F. Hehemann and G. Mervin Ault. Wiley, 1959, 544 pp., $17.50. A compilation of reports presented at the symposium on high-temperature materials held April 16-17, 1957, in Cleveland, Ohio, sponsored by the High Temperature Alloys Committee, Institute of Metals Division, The Metallurgical Society, American Institute of Mining, Metallurgical and Petroleum Engineers. This is a summary of developments and of know-how on materials for use above 1500 F. Chapter coverage is as follows: (I) Cobalt—and Nickel—Base alloys; (II) Cermets and Intermetallics; (III) Refractory Metals; (IV) Strengthening by Dispersion of Insoluble Particles; (V) Vacuum melting and Its Effects on Properties; (VI) Effect of Testing Environment on Properties; (VII) Oxidation Resistance.

SPACE TECHNOLOGY. Edited by Howard S. Seifert. Wiley, 1959, 1188 pp., $22.50. Contributions from 38 specialists covering the major phases of space technology. This book is based on a series of comprehensive graduate-level lectures presented by the Department of Engineering and Physical Sciences, University Extension, University of California, in cooperation with Space Technology Laboratories, Inc. These analytic lectures are treated under six major groupings: (I) Why Space Technology?; (II) Flight Dynamics; (III) Propulsion and Structures; (IV) Communications, Guidance and Control; (V) Man in Space; (VI) Present and Future Applications of Space Technology.

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Circle 49 on Inquiry Card

New Parts and Components

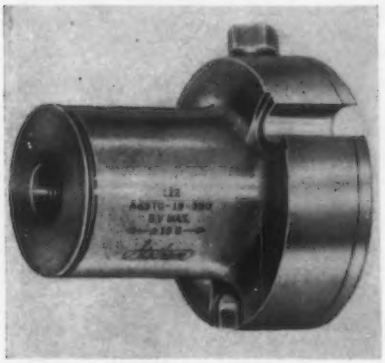
Cryogenic Pumps

The operational temperature range of these utility pumps, for ground support and test stands, is 400° to 1200°F, pressure range from absolute 0 to 10,000 psi. They are run by electric motor, but may also be coupled to other drives such as steam, gas turbines, and hydraulic motors. The pump illustrated is the 150 gpm type, with 20-ft head rise, 6-ft suction head (NPSH), 2½-in. suction, and 1½-in. discharge.—Hydrodyne Corp.

Circle 62 on postcard for more data

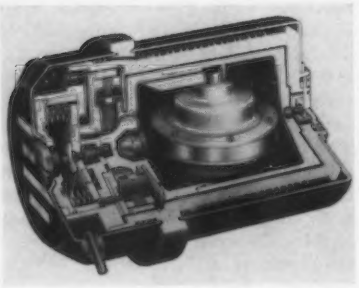
Accelerometer

Linear accelerometer, Series A 65, responds flat within ± per cent from static to 830 cps. It features the unbonded strain gage principle, with resistive elements arranged in a complete Wheatstone bridge. Models are available from ±7.5g to ±150g. Requiring an excitation



of 5v d.c., or a.c., accelerometer has a nominal output of ±20 mv. Its combined non-linearity and hysteresis is less than ±1 per cent of full-scale output. Rated for ambient temperature limits of —40° to 200°F.—Statham Instruments, Inc.

Circle 63 on postcard for more data



Ceramic Gyro

Eight-oz ceramic gyroscope, for space applications, spins at 24,000 rpm on a 0.000025-in. film of helium. Combination of sapphire-hard ceramic and gas-bearings is claimed to have sharply reduced prime causes of drift, and extended theoretical life-span of unit indefinitely. In stability tests, ceramic material has been subjected to temperatures from –85°F to 1500°F and has retained original dimensions within 0.000002 in. Gyro has 2.0-in. diam, and is 2.82 in. long.—Minneapolis - Honeywell Regulator Co.

Circle 64 on postcard for more data

Missile Clock

New 400 cps frequency standard features extremely high stability under rugged environmental conditions and varying input voltages.

Its most important application will be as a 'master clock' type to assure generation of precise and stable frequencies for missile guidance and fire control systems.

Called the Model BM400, it has input requirements of 28 dc (25-29 vdc), 1Vrms ripple. Maximum power required for the unit's oven and oscillator circuitry is 11 watts. —Electronics Div., Bulova Watch Co.

Circle 65 on postcard for more data

Encoders

Size 18 shaft position-to-digital encoders use disc-and-brush principle to convert shaft-position data into binary readout. Model 773 is a 13-bit encoder with a resolution of 128 counts per input shaft revolution and a full-scale capacity of 8192 counts. The V-scan feature of its pick-off brush circuit features accuracy no less than the least

significant digit in 8192 binary counts. Model 773 weighs 7.6 oz and has a starting torque of less than 0.2 in.-oz and a moment of inertia of 0.0480 oz-in.^{2}—Librascope.

Circle 66 on postcard for more data

Thermal Switch

Rugged, precision thermal switch responds to tip temperature rather than shell temperature. Designated the "Tip-Stat," it is used to control inner temperature. Used on

aircraft generators, it serves as warning device to actuate a control when windings overheat; also measures bearing temperature. Operates from —20°F to 550°F, and

continued on next page

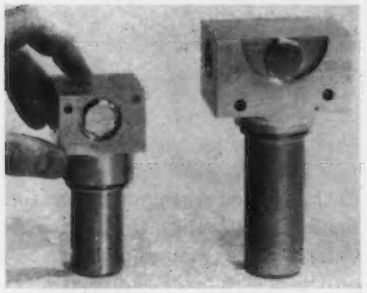
New Parts and Components

has a reaction time less than 0.5 sec. Weighs 0.9 oz, is 2.5 long with a max diam of 0.5 in. Its rating is 1.5 amp at 28 v d.c. and 115 v a.c. resistive load. Meets MIL-S-25345 requirements.—Control Products, Inc.

Circle 67 on postcard for more data

Hydraulic Filters

High-pressure filters feature light weight, compact design and are rated at 3.5 gpm and 10 gpm. Nominally rated at 10 microns,



they contain pleated, resin-impregnated cellulose fiber elements. Both assemblies have a pressure drop of 30 psig at their respective flow rates using MIL-H-5606 fluid at ±10°F. They are for temperatures from —65°F to 275°F. Rated operating pressure for both types is 3000 psi with impulse burst pressure of 7500 psi. The 10 gpm assembly weighs 1.3 lb; the 3.5 gpm unit weighs 0.7 lb.—Bendix-Michigan.

Circle 68 on postcard for more data

Miniature Pressure Balance

Type 4-332 precision pressure balance is for use with Electromanometer precision pressure measuring system. Transducer portion of system includes a standard or high-speed servoamplifier assembly. Measures 4 x 3 x 2½ in. and weighs 2.6 lb. Seven pressure ranges are available from 0 to 1½ to 0 to 150 psi differential. Output of the transducer is ±100 volts full scale. Combined effects of linearity and hysteresis are less than 0.05 per cent.—Consolidated Electrodynamics Corp.

Circle 69 on postcard for more data

Water Pumps

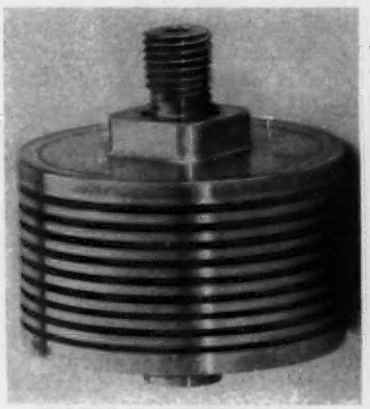
These are lightweight, high-efficiency pumps for aircraft drinking water systems. Pump body is of stainless steel; all parts in contact with water are approved by the Public Health Service. Features a 0.14 hp continuous duty motor, and weighs 1.65 lb with thermal protector. Other specifications include: 400 cyc frequency, 115/200 volts, 4 poles, 3 phase, 11,400 RPM. Pump pressure rise is 25 psi at 5 GPM.—Task Corp.

Circle 70 on postcard for more data

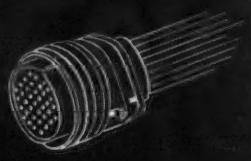
Sensory Bellows

Principal application to date of this lightweight bellows has been in LOX pressure regulation; it is also suitable for other applications. It's fully machined, not formed, and designed for a maximum pressure differential of 100 psi and a temperature range of —450°F to 1000°F. Available in aluminum, stainless steel, nickel alloys, and other materials in an infinite range of diameters and strokes.—Hydrodyne Corp.

Circle 71 on postcard for more data



BENDIX
MS-R
ENVIRONMENT RESISTANT
Connectors



Bendix MS-R series are the small, lightweight, more efficient and compatible environment resisting class of connectors as specified in the latest version of MIL-C-5015.

Main joint and moisture barriers at solder weld ends have integral "O" rings. Grommet design of "slippery rubber" is sealing medium for individual wires. This provides easier wire threading and friction-free travel of grommet over wires.

Many other features are described in MS-R Bulletin. Send for your copy today, or

Call your Avnet Applications Engineer

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AVNET•5877 Rodeo Rd., Los Angeles 16, Cal.- UP 0-6141
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AVNET•4180 Kettering Blvd., Dayton 39, Ohio- AX 8-1458
AVNET•2728 N. Mannheim Rd., Melrose Park, Ill.- GL 5-8160
AVNET•1262 N. Lawrence Sta. Rd., Sunnyvale, Cal.- RE 6-0300

Circle 40 on Inquiry Card

New Electronic Products

Shutoff Valve

This shutoff valve can be actuated by a motor, solenoid, hydraulic or pneumatic energy. It uses a rotary shear seal. Flow can be positioned from zero to 10 gal per min. Operating pressure is 3000 psi. Ports meet AND 10050-16 specification and either fluids or gases may be controlled. Low pressure drop (10 psi max at full flow), low actuation torque and zero leakage are its principal characteristics. — Vinson Engineering & Sales Co.

Circle 72 on postcard for more data

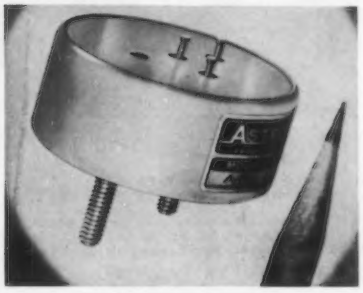
Pressure Components

Two pressure components are reported to have exceptional sensitivity and reliability.

One, the A-21 pressure switch, attains its sensitivity by means of a stretched diaphragm pressurized by dry nitrogen. It uses solid Paliney contacts for simple, rugged and dependable operation.

The other, the A-6 pressure transducer, has an overall accuracy of ¼ per cent up to 100 psi. Special design features include the integrally-machined flat diaphragm and completely sealed inductive pick-off coil.—Astromics, Div. of Mitchell Camera Corp.

Circle 73 on postcard for more data



Thermocouple Reference

Miniature, heated multi-channel unit is designed to replace the conventional ice bath as reference temperature for Thermocouples. It meets the requirements of MIL-E-5272A for acceleration, vibration altitude and humidity. Unit is available in either adjustable (±3.0°F stability) or non-adjustable (±1.5° F stability) regulators. The temperature stability is insured by the use of temperature - current regulating heater wire.

The reference temperature is adjustable to 250°F when adjustable regulator is provided. It is available in either 115 or 28 volt AC or DC. Automatic reference junctions are also available. — Aero Research Instr. Co.

Circle 74 on postcard for more data

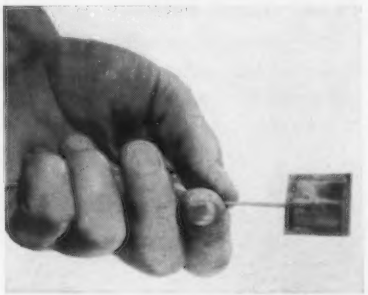
New Voltage Monitor

Automatic voltage monitoring system is designed to detect and signal over-voltage and under-voltage in any of eight separate external power supplies. Designated Model VSIB-1, it contains a switch-type magnetic amplifier for each of the eight sensing channels, plus a DC voltage reference unit and a resistor assembly. The device operates from a standard 120-V, 400-cps power source. Each of the magnetic amplifiers and other components is epoxy encapsulated mineral-filled, molded case. — Magnetic Controls Co.

Circle 75 on postcard for more data

Adhering Temp Sensor

Thermal-Ribbon is a high-temperature sensor that can be stuck to any clean, dry metallic surface. It is operable to 500°F. Resistance is 676 ohms at 25°C, and varies at a rate of 3.06 ohms°C. It comes



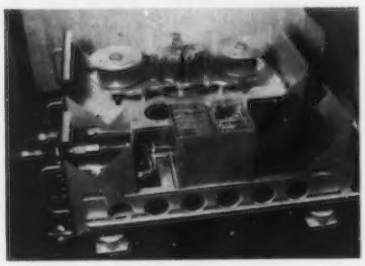
as a 1¼-in. square and is 0.050-in. thick. Weight is 4 grams, including the 36-in. teflon leads. Accuracy is ±1 per cent. Calibration curve is provided.—Minco Products Inc.

Circle 76 on postcard for more data

Flight Data Recorder

Transistorized, lightweight, tape recorder was developed for inflight data recording on airliners. Sixty-five flight variables can be recorded. Ground playback of tape gives precise means of determining time and kind of maintenance needed. Playback can be accomplished through aircraft instrument display, a Visicorder, a digital counter and printer, or a digital computer.—Minneapolis-Honeywell.

Circle 77 on postcard for more data



New for Production

X-Ray Unit

The Baltospot 150, a new, lightweight, portable x-ray unit available in 2 model versions, features a power range of 150 KV-3MA and penetration of 1⅞ in. steel.

Unit also incorporates newly designed 360 deg x-ray tube for circumferential radiography. A diaphragm makes it adaptable to single-beam or directional use. —Balteau Electric Corp.

Circle 78 on postcard for more data

Bright Annealing

High-production furnace allows bright annealing of stainless steel at production rates as high or higher than existing anneal and pickle lines at approximately 50 per cent lower cost per ton. It prevents formation of scale on the strip through the utilization of very pure and dry (–60 deg F dewpoint) hydrogen or dissociated ammonia atmosphere. —General Electric Co.

Circle 79 on postcard for more data

Tote Box

Linear polyethylene tote box weighs less than 10 lb, can hold over 300 lb. It measures (I.D.) 26¾ in. x 25 in. x 12 in. deep and stacks at 11 in.

Box is chemically resistant to acids, alkalis, oils. Linear polyethylene is ideal for degreasing and washing operations and maintains its characteristics at temperatures below zero and up to 250 deg F. It will not rust, splinter or corrode. —Patti Plastics Corp.

Circle 80 on postcard for more data

Eliminates Re-Draws

Process restores printability of original tracings by washing with mild soap and water, thus eliminating re-draws.

The wash method uses a waterproof drafting material (K&E's Herculene film) and a washable

plastic pencil line (Staedtler Pencil Company's Duralar).—Keuffel & Esser Co.

Circle 81 on postcard for more data

Boring Head

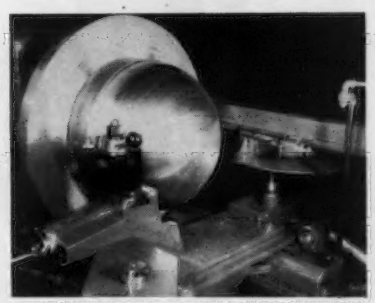
DBL Boring Head series possess new design, a small head. The double-hole bar holders will be available in three sizes—two, three and four inch diameters. All will feature cross holes to permit the boring of extremely large holes.—Criterion Machine Works.

Circle 82 on postcard for more data

Lathe

Speed lathe eliminates the need for speed control cams and computations.

Lathe provides constant cutting speed at any point, regardless of contours. Lathe headstock is



equipped with a 24-speed transmission plus a variable speed drive. "Combined feeds" operation makes larger machining capacities possible. In extreme cases, longitudinal and cross feed ratio can now be increased to provide a resultant tool path at 10 deg. or even 5 deg to the center-line.—Lodge & Shipley Co.

Circle 83 on postcard for more data

Cleans Components

Automatic "washing machine" cleans large tubes or cylindrical shells, as well as a variety of components. *continued on next page*

MISSILES
BREATHE TOO
YOU KNOW...

...that's why major missile manufacturers specify MIDGET LOUVERS

In seven sizes to meet your needs — one inch through six inches. Available in chrome, aluminum and copper rustproof finish . . . installs easily and quickly. Write for our catalogue sheet.

"REGULAR" —with screen and all-weather deflector.

"LD"—screened for interior and protected exterior locations.

MIDGET LOUVER COMPANY
6 Wall Street • Norwalk, Conn.

Circle 41 on Inquiry Card

BEST WAY TO SEAL HOLES!

LEE PLUG

Simply place plug in reamed hole. Drive in tapered pin until ends are flush. Controlled expansion causes grooves to "bite" into casting, assures a bone dry seal that withstands pressures up to 40,000 psi. Now widely used on aircraft and missiles, and for pumps, servo valves, regulators, etc.

Pat. #2,821,323

LEE COMPANY
OLD SAYBROOK CONN.

WRITE TODAY FOR COMPLETE ENGINEERING DATA

Circle 42 on Inquiry Card

New for Production

Parts are put through a complete cycle of automatically timed and sequenced operations that include cleaning, rust-inhibiting and drying. Timing can be varied to permit handling four to six work loads per hour.—Ransohoff Co.

Circle 84 on postcard for more data

Microfilming

High-speed machine microfilms engineering drawings, then registers and photographs them.

Sheets up to 22 in. x 34 in. are handled as well as roll drawings up to 42 in. wide. Machine microfilms up to 1200 drawings per hour.—The de Florez Co.

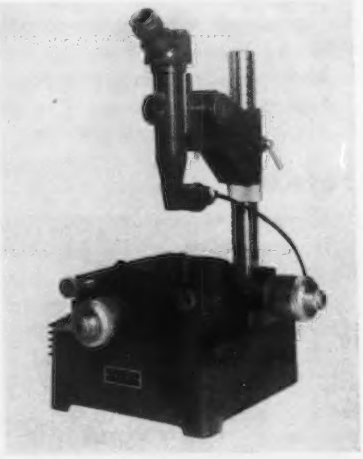
Circle 85 on postcard for more data

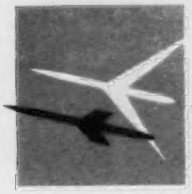
Toolmaker Microscope

New model of the SIMPLEX Toolmaker Microscope is being offered as an addition to the Leitz line. Tilt of the tube to the helix angle has been dispensed with.

A 360 deg rotary stage is provided to permit measurements in polar coordinates. Total range is 2 in. x 2 in. with direct micrometer readings in .0001 in.—Optometric Tools.

Circle 86 on postcard for more data





Worth Asking For

Patents

Revised pamphlet, "Preparing for Patent-hood," tells what to do with your invention idea; when to talk with a patent attorney; importance of dates and a verifier, about the patent office, etc.—*Trak Electronics Co.*

Circle 87 on postcard for more data

Fiberglass Laminates

"The Fabric of Space," eight-page brochure, describes firm's capabilities in fiberglass laminates.—*U. S. Chemical Milling Corp.*

Circle 88 on postcard for more data

Silicones

"Materials Handbook" contains engineering data and processing information on silicones.—*Dow Corning Corp.*

Circle 89 on postcard for more data

Cobalt

Data sheet covers recently developed cobalt-containing alloys and provides information on composition, physical and mechanical properties, thermal treatment, fabrication, corrosion resistance, forms available, and applications. — *Cobalt Information Center.*

Circle 90 on postcard for more data

Teflon

"Basics in the machining of Teflon," 12-page booklet. — *Plastic Products Div.*

Circle 91 on postcard for more data

Epoxies

Ten applications of epoxies in the foundry enabling savings of up to 60 per cent are outlined in a new three-color, eight-page brochure. — *Furane Plastics Inc.*

Circle 92 on postcard for more data

Vernistat Products

Comprehensive catalog describes design features, applications, and operation of "Vernistat" a.c. potentiometers and "Vernistat" adjustable function generators.—*The Vernistat Div., Perkin-Elmer Corp.*

Circle 93 on postcard for more data

Power Systems

Bulletin A-5239, discusses development of complete and separate power generating systems leading up to the present Vickers line of packaged flight vehicle power systems.—*Aero Hydraulics Div., Vickers, Inc.*

Circle 94 on postcard for more data

Vacuum Pumps

Pamphlet on line of high vacuum pumps and fittings.—*Ultek Corp.*

Circle 95 on postcard for more data

Explosive Cartridges

Technical data sheet 2100 describes a standard series of electrically-initiated pressure-producing explosive cartridges.—*Holex, Inc.*

Circle 96 on postcard for more data

Servo Design

Brochure describes simplified procedure and calculations necessary to obtain optimum performance from 2nd and 3rd order Servo Systems.—*M. Ten Bosch, Inc.*

Circle 97 on postcard for more data

Re-entry Vehicle

Development of re-entry vehicles for Thor and Atlas outlined in a new booklet.—*Missile and Space Vehicle Department, General Electric Co.*

Circle 98 on postcard for more data

Refractory Metals

Chart shows complete properties of tungsten, tantalum, molybdenum and columbium.—*Fansteel Metallurgical Corp.*

Circle 99 on postcard for more data

Quality Control

"Quality Control and Research," a 24-page booklet.—*Scientific Apparatus Makers Asso.*

Circle 100 on postcard for more data

Graphite

Brochure contains charts showing graphite's typical physical properties and chemical content.—*Great Lakes Carbon Corp.*

Circle 101 on postcard for more data

Drop Forgings

Brochure outlines diversified design, engineering and processing services available in ferrous forgings.—*Union Forging Co.*

Circle 102 on postcard for more data

Balancing Machines

Two complete lines of static-dynamic balancing machines are described in 20-page Bulletin 60.—*Tinius Olsen Testing Machine Co.*

Circle 103 on postcard for more data

Thermocouple Use

New 26-page thermocouple catalog contains valuable information for design, use and application of thermocouples.—*Temptron Inc.*

Circle 104 on postcard for more data

Welding Manual

Instruction manual describes operation and use of the carbon arc welding process.—*Arcair Co.*

Circle 105 on postcard for more data

Insulated Wire

Pamphlet describes ceramic insulated wire for high temperature and nuclear applications. — *Secon Metals Corp.*

Circle 106 on postcard for more data

Microfilming Methods

Brochures describe "Micro-Flo" system.—*Delta Blue Print Co.*

Circle 107 on postcard for more data

Anemometer

Wind Velocity Transmitter and a portable wind recording station featured in wind instruments bulletin.—*W. & L. E. Gurley.*

Circle 108 on postcard for more data

Precision Comparator

Folder describes Mueller Mikrom Comparator.—*Mueller Gages Co.*

Circle 109 on postcard for more data

Industrial Diamonds

First issue of "Diamond Data," firm's monthly bulletin, includes article "The Total Economics of Tool Use."—*Engelhard Industries, Inc.*

Circle 110 on postcard for more data

Flash-Butt Welding

Brochure describes resistance flash-butt welding process; illustrates types of clamping, flash and upset mechanisms. — *The Taylor-Winfield Corp.*

Circle 111 on postcard for more data

Relays

24-page catalog of sub and microminiature hermetically sealed relays.—*Filtors, Inc.*

Circle 112 on postcard for more data

Teletype

Literature describes "Teletype 28" control mechanism and gives a basic explanation of teletype equipment, its operation and application.—*Teletype Corp.*

Circle 113 on postcard for more data

Nuclear Instrumentation

Catalog 59 gives information on our radiation detectors, personnel protection equipment and area surveying instrumentation.—*Nucleonic Corp. of America.*

Circle 114 on postcard for more data

Men on the Move

Bastian Hello
Martin

Richard DeMott
International
Resistance Co.

R. E. Horner
General Electric

Allen C. Munster
Philco

BASTIAN (BUZZ) HELLO, appointed program manager for the Martin Co. rocket booster portion of the Air Force Dyna-Soar project.

RICHARD DEMOTT, appointed government sales manager at International Resistance Co.

ROBERT J. LODGE, named manager of engineering test Rocketdyne Div., North American Aviation.

R. E. HORNER, named manager-marketing for the Light Military Electronics Dept., General Electric Co.

ALLEN C. MUNSTER, appointed director of research-operations at Philco Research Div.

ROBERT A. TRENNERT, named manager of the Western sales region for Grand Central Rocket Co.

Geoffrey Robillard
Jet Propulsion Lab

Robert J. Garon
Wyle Laboratories

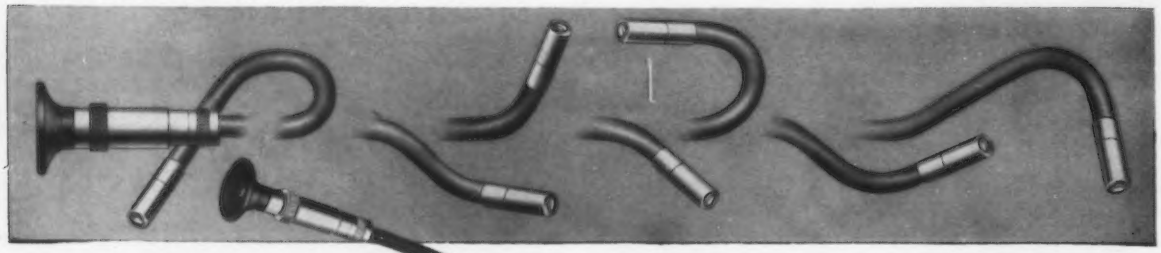
GEOFFREY ROBILLARD, appointed chief of the newly formed Propulsion Div. at the California Institute of Technology Jet Propulsion Laboratory.

ROBERT J. GARON, appointed general manager of Wyle Laboratories.

JOHN J. JAROSH, appointed manager of inertial devices and DR. WILLIAM L. PARKER named manager of guidance systems at the engineering department research and development laboratories, Hughes Aircraft Co.

G. J. RAUSCHENBACH, named manager of The Martin Company's corporate office.

DR. HOWARD S. SEIFERT, named director of the Professional Development Staff, United Technology Corp.



Focusing eyepiece provides clear definition at various working lengths.

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A.C.M.I. Fiber Optic *Flexible* Borescopes

FOR visualization in inaccessible curved areas where a flexible instrument capable of adapting itself to irregular contours is required.

Fiber Optic Borescopes are equipped with focusing eyepiece and fixed or movable objective as required. Illumination can be provided by a flexible fiber optic light carrier with an external light source or an annular fiber optic light carrier attached to the image carrier. Fiber optic light carriers are particularly advantageous for transmission of intense cold light to inaccessible or hazardous areas.

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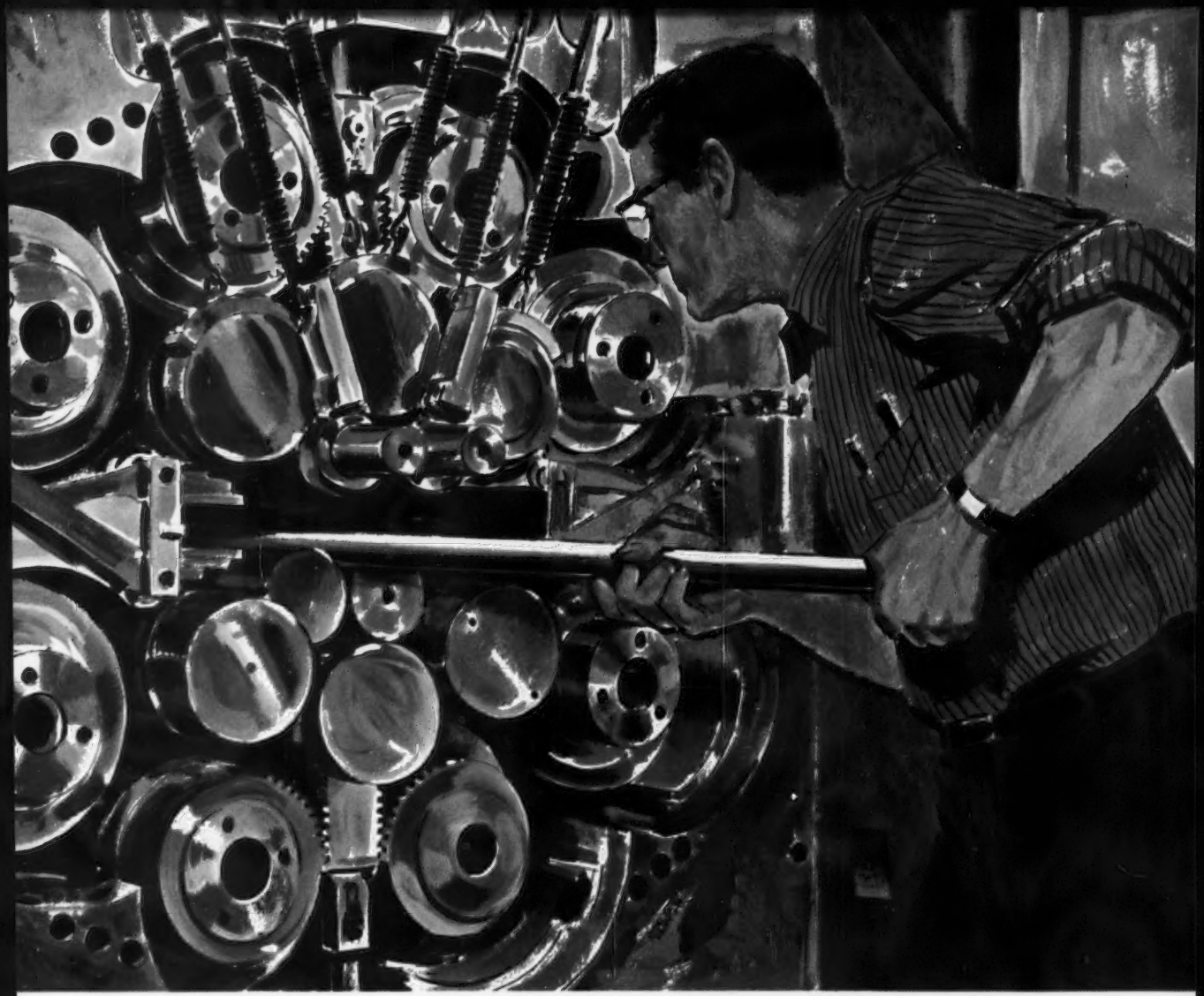
Circle 19 on Inquiry Card →



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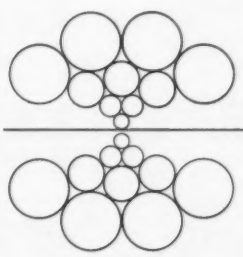
If you now use this type of product or have future requirements for it we would welcome the opportunity of working with you.



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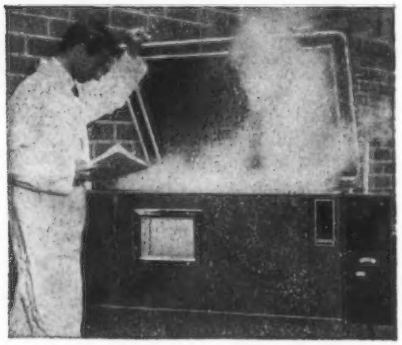
WITH COMPLETE ACCURACY AND RELIABILITY

...WITH PURECO CO_2 "BLAST COLD"



Quick test chamber temperature pull-down. (Direct cooling)

The Pureco CO_2 *Blast Cold* process provides an extremely high rate of temperature pull-down. Temperatures can be reduced from as much as 2000°F to —100°F in minutes. Fluctuation of temperatures caused by "over-ride" are eliminated ... tolerances of ± ½° are easily achieved. The possibility of refrigeration failure is eliminated. The Blast Cold process is completely reliable.

Capital investment and maintenance costs low.

The equipment necessary for the Pureco CO_2 *Blast Cold* process is extremely simple. CO_2 receivers are normally supplied and maintained by Pure Carbonic on the customer's premises. Since many environmental testing jobs are scattered around in plants, Pureco now supplies portable CO_2 receiver units of 1000 lb. capacity in addition to fixed units up to 60 tons or more capacity.

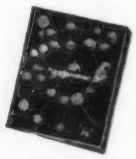
CO_2 liquid for indirect cooling.

Pureco CO_2 liquid is discharged directly into a circulating refrigeration solution when it is necessary to keep the test chamber free of CO_2 atmosphere.

Pureco "DRY-ICE" a quick, low-cost refrigerant for direct or indirect cooling.

Pureco "DRY-ICE" provides a simple, inexpensive method of reducing test chamber temperatures down to —109°F.

New Pureco booklet "How Carbon Dioxide Serves You". Write for free copy.



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PURE CARBONIC

Pure Carbonic Company, A Division of Air Reduction Company, Incorporated
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Industry Notes

Space Pilot Training

Test pilots for Dyna-Soar and advanced Air Force space programs of the future are training at Edwards Air Force Base, Calif.

A larger number of pilots are involved than in the Mercury program, according to a Pentagon official. Most are qualified test pilots with degrees in aeronautical engineering.

Lockheed Modifying Electra After Crashes

Extensive "torture tests" on the Lockheed Electra indicate that structural weakness in the engine mounting and power package may have contributed to two crashes within the past year. A program is underway to modify the plane.

Lockheed engineers said oscillations and instability occured during wind tunnel tests on the engine nacelle and power package. The oscillations began—and spread to the wings—after stiffness and bending strength of the nacelle and power package were reduced. Air turbulence was also cited for the crashes.

One Electra will be modified and tested before changes are made on the other 140-or-so planes in service. The aircraft will continue to fly 100 mph under top speed until the Federal Aviation Agency approves the modified plane. Lockheed estimates cost of modifications, which entail new structural parts, will reach $25-million.

A giant test facility will be built at Huntsville for mechanical, structural and operational tests on the multistage Saturn.

NASA will award a contract for a 204-ft-high structural steel tower, a reinforced concrete control building, electric elevator and derrick.

Man From Inner Space

Walk down a corridor at the Bridgeville Plant of Universal-Cyclops Steel Corp. and you might meet this fellow on his way to work.

He wears a modified Air Force MC-2 pressure suit, carries his own oxygen supply and cooling unit on his back, and is "plugged in" to power outlets.

This "spaceman" works at the firm's new InFab (Inert-Fabrication) facility—an 84,000 cu.ft. area enclosed by welded steel plate. In picture, he's bringing a molybdenum ingot into the plant through a tube-shaped materials lock.

InFab was designed and built by the Refractomet Div. in cooperation with the Navy. Purpose: make products from refractory metals such as molybdenum and tungsten.

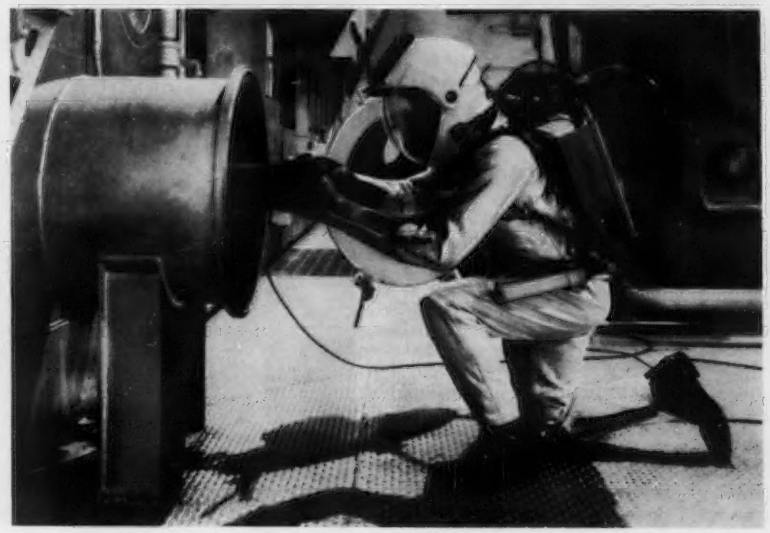
One reason for the suit: enclosure is filled with argon during metal processing. (Refractory metals are contaminated by elements in air.) The four-layer, gas-tight suit also protects against thermal and ultraviolet radiation. It is covered by a reflective aluminized outer garment.

Refractomet Div. is beginning experiments on hot machining and welding of the refractories. Men within the facility will use a ten-ton crane to move ingots to an automatic impactor. Ingots are broken down here at temperatures up to 4500°F.

Billet and sheet bar can then be transferred to a remote—controlled rolling mill also within the argon atmosphere. Temperatures here will range up to 4000°F. Furnaces complete the array of equipment.

The "men from inner space" move in and out of InFab through three locks. Two personnel "crash" doors are also available.

Suit by David Clark Co. Air supply and cooling unit pack by The Firewel Co. Argon purification system — maintaining purity level exceeding 99.995 per cent—by Air Products Inc.



Industry Notes

X-15 Explosion

X-15 explosion during a series of ground stop-restart tests with XLR-99 engine apparently occured in the section between the oxygen tank and the engine.

This would indicate either the ammonia fuel tank or the small hydrogen peroxide tank as explosion point.

The run-up tests were pre-flight checkouts. First flight checkout of XLR-99 powerplant was to have taken place about a week later.

Front section—with pilot Scott Crossfield in the cockpit — was pushed forward about 20 ft but was not badly damaged. The new engine at the rear of the ship was also intact. About a month's delay in the flight program was expected. Second flight-type engine is now at Edwards AFB for installation in a second X-15 craft.

Dyna-Soar Manager Cites Systems Role

George H. Stoner, Boeing Aircraft's Dyna-Soar program manager, estimated in a talk at the Air Materiel Command's aeronautical systems center that "approximately 90 per cent" of a typical space program now underway is programmed and budgeted on the basis of existing techniques. He listed three basic management principles in developing space systems:

- Make use of experience by arranging the systems configuration to take advantage of existing proven hardware and techniques.
- Exploit every possible technique to maximize the reliability of hardware before flight test.
- Plan each flight test to accomplish a maximum proportion of the total development progress.

Polaris Fire Control System

Developed on a "crash" program, the Polaris fire control system consists of a complex array of computer units, control and switching consoles, missile test equipment and other electronic equipment.

System prepares Polaris for firing by computing missile geoballistic parameters which establish the launch point to target point flight. It erects and aligns the missile inertial system, determines if Polaris is ready to fire, and provides the firing command.

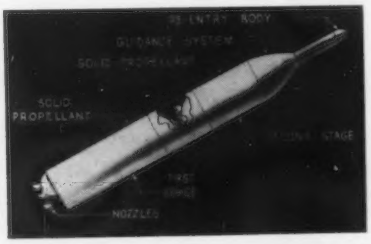
Aboard the submarine fire control equipment goes into a dust-free, temperature-controlled and well-lighted room called the Missile Control Center. Cabling is connected below the deck to provide maximum room at operating stations.

A geoballistic computer in the submarine works constantly, plotting the vessel's position. It considers distances traveled, motions, other navigational information. This information is passed to the fire control computers, where it is converted from analog to digital form. Just prior to launching, the fire control feeds its data to the digital computer in the Polaris guidance system.

At launching, the Polaris inertial guidance takes over.

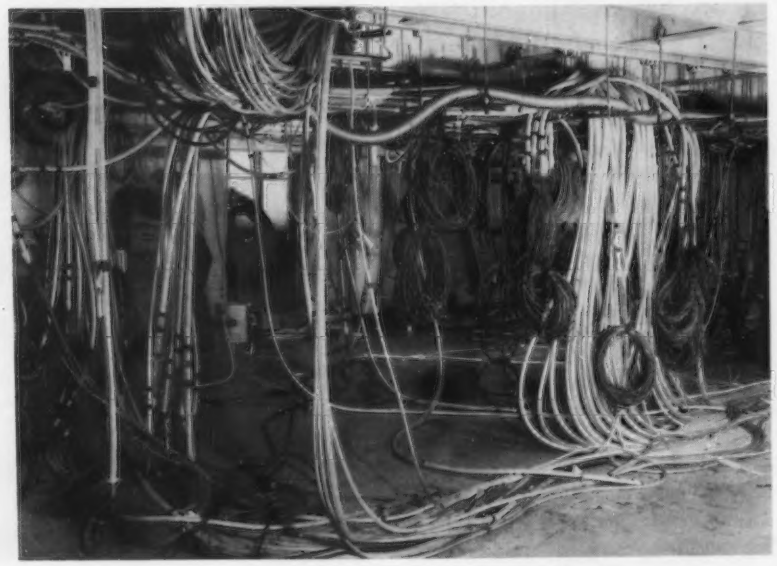
Equipment for the fire control system is produced and tested at General Electric's Ordnance Dept., Pittsfield, Mass.

Testing simulates several of the physical conditions aboard the sub. Systems test berths utilized bolted steel to minimize noise. All steel framing members were grounded with a weld spot to provide continuing of grounds throughout the test berth, simulating the submarine all steel deck.



POLARIS. Digital computer in missile receives data from fire control to maintain constant position until launching.

MILES AND MILES of wiring and cabling will be installed beneath the fire control equipment in Polaris-firing subs.



Rocketdyne Picked for Saturn Engine

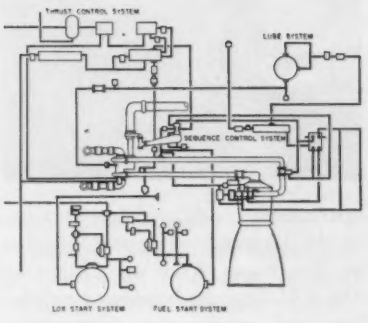
Rocketdyne will develop the 200,000-lb-thrust liquid hydrogen engine which is planned for the second stage of the advanced "C2" Saturn.

The North American Aviation division was selected by NASA from five bidders. The competition also included Aerojet - General Corp., Pratt & Whitney, General Electric, and Bell Aircraft.

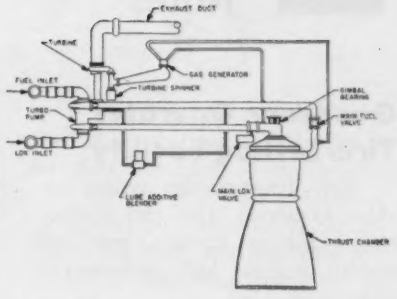
Rocketdyne estimates development of the new engine, designated the J-2, will take about three years and cost some $44-million. The firm has already static-test-fired the 1,500,000-lb-thrust Saturn booster. This consists of a cluster of eight H-1 liquid propellant rocket engines.

The new J-2 is slated to be used in a cluster of two or four between the booster and two other liquid hydrogen upper stages.

JUPITER S-3D ENGINE SYSTEM



SATURN H-1 ENGINE SYSTEM



Saturn Plan

	C1 (ready: 1963)	C2 (ready: late 60's)	C3 (plans not definite)
1st Stage	Cluster of 8 H-1 engines	Same as C1	Same as C1
2nd Stage	Four 20,000-lb-thrust XLR-115 hydrogen engines	Two or four 200,000-lb-thrust LO2-LH2 engines (J2)	Four J2's
3rd Stage	Two 15,000-lb-thrust XLR-115's	Four XLR-115's (same as C1 2nd stage)	Two J2's
4th Stage		2 XLR-115's	Four XLR-115's
5th Stage			Two XLR-115's

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Eliminate water hammer and pipeline bursting.
Save piping and plant costs with guaranteed surge limits.
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Designed primarily for shut-down or shut-off application, this unit is used in pumping plants, irrigation systems, fire control on rocket test stands, municipal water systems, etc. Of the water interface type, the Pulsco swirl principle reduces pressure and reduces shock and surge resulting from kinetic energy within the pipeline, this by compressing gas within the chamber and by friction through the swirl chamber.
Guaranteed not to recycle, this Pulsco Spherical Shock Trap is built for pressures to 200 PSIG and up. Sizes from 34 to 102 inches diam.

PULSCO *Bellows* SHOCK TRAP
For AIRCRAFT AND MARINE FUEL LOADING SYSTEMS JET FUEL AND GASOLINE

Take the "hammer" out of high velocity fuel lines — removes the danger of broken lines, meters, and overstressed loading equipment. Assure correct meter readings consistently with this Pulsco scientifically designed Bellows Shock Trap — the best for quick STOP and GO liquid lines.
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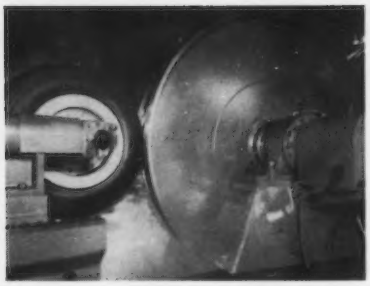
Industry Notes

Goodyear Operates Tire-Testing Facility

New dynamometer system enables Goodyear Tire and Rubber technicians to develop, test and qualify tires for high performance jet aircraft.

A mammoth steel flywheel, 10 feet in diam., simulates tortures and strains of landings and take-offs up to speeds of 320 miles per hour. On a second unit, one tire is pressed against another, tread to tread, to duplicate actual load conditions, and then accelerated to speeds of more than 500 mph. This "tire-on-tire" facility at Akron, Ohio, is the only one of its kind in the U.S.

Goodyear engineers can now "program" the actual take-off and landing cycle, duplicating all of the



operational conditions, from taxiing to the tremendous impact of tires as they touch down on a runway. The 8,600-hp machine has acceleration and deceleration capabilities which exceed any present day or anticipated future aircraft requirements.

The flywheel can simulate take-off and taxi loads exceeding 80,000 lb. Acceleration characteristics, constant or variable, range from zero to 24 ft. per sec. Yaw and camber characteristics can be duplicated on angles up to 15 degrees.

Testing system will also be used for basic research on materials for tires of future aircraft.

AM—355: high psi

Multiple strips of ultrahigh-tensile AM-355, a precipitation hardening stainless steel, have been wound, then spotwelded, into a strong cylindrical rocket chamber withstanding 305,000 psi hoop stress.

Ryan Aeronautical built and tested rocket motor cases in quarter scale, then adapted the findings of this research to full-scale motor case requirements. The technique of spot welding together many layers of foil gage stainless steel alloy reportedly stacks up as one of the best methods of restraining high surge pressure which builds up in a rocket motor case.

In metal tests, engineers found that AM-355 (subzero cooled, cold rolled and tempered) absorbed the greatest amount of energy. The steel was developed by Allegheny Ludlum Steel Corp.

High psi stresses usually start at about 240,000 psi.

Aerospace Log

May 13—Project Echo passive communications sphere fails to orbit. Failure in first use of Delta three-stage rocket.

May 15—Russia orbits 4½-ton satellite containing a "dummy spaceman."

May 20—Atlas fired more than 9000 miles from Canaveral.

May 24—Midas orbited from Cape Canaveral.

May 27—Titan makes fifth 5000 mile flight.

May 27—Nike Zeus test model fired.

June 8—X-15 explodes during ground run-up test.

SILICONE NEWS from Dow Corning

Photo courtesy of Douglas Aircraft Company

Fuel Resistant O-rings for Jets

The DC-8 Jetliner uses more than 500 flexible couplings on fuel lines. Leakage at any coupling is prevented by two rubber O-rings that must retain their rubbery properties and continue to seal as an O-ring should, despite constant contact with jet fuel.

Douglas engineers, after extensive tests, chose Silastic® LS, the Dow Corning fluorosilicone rubber, as the material for O-rings. Silastic LS resists the attack of fuels, oils, most hydraulic fluids and solvents . . . doesn't swell, or become tender.

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first in silicones

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MIDLAND, MICHIGAN

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Contracts

Convair Div., General Dynamics—$188,000,000 Air Force contract for continued production of Atlas.

AC Spark Plug—$84,000,000 from the Air Force for research and development of inertial guidance systems, including ground operating equipment, for Titan.

National Carbon Co., Div of Union Carbide—$12,000,000 from the Air Force for three years R & D on graphite for missile and space vehicle components.

Food Machinery and Chemical Corp.—$20,000,000 total contracts for multi-million-pound quantities of Dimazine storable high energy liquid rocket fuel for the Air Force.

Raytheon Co. — $13,560,853 from the Army for Hawk missiles.

General Electric Co. — Over $60-million to the Large Jet Engine Dept. for J79 turbojets. Air Force contract.

R & D Briefs

Ion engine which could be installed in a satellite with only slight modifications will be designed and built by Electro-Optical Systems Inc.

Zero gravity experiments at the Tapco Group of Thompson Ramo Wooldridge recently included pioneering work in boiling and condensing of closed Rankine cycle working fluids.

Plasma jet heated to 20,000°F traveling at 9000 mph was produced in new-type "crossed field acceleration" wind tunnel. This prototype tunnel was developed by Allis-Chalmers' Defense Products Div. and M H D Research Inc.

Frontiers of refractory metals are being studied at Chance Vought's Aeronautics Div. for the Air Force. Study will enable engineers to mathematically predict forming limits of the as yet untried superalloy and refractory metals.

DESIGNING DUST-FREE ENCLOSURES

by Robert J. Schiesser
Section Leader
Instrumentation Laboratory
Massachusetts Institute of Technology

It is often difficult to find a commercially available enclosure to suit exact needs. The laboratory producing precision parts may profit by designing the enclosure for itself.

Refined fabricating techniques are necessary; hence, the laboratory will usually draw up a preliminary design and then consult with a commercial fabricator.

In developing an enclosure for gyro assemblies, we drew up a preliminary design; constructed a wooden model; contracted with S. Blickman, Inc., Weehawken, N. J., to turn out a prototype based on the design. A preliminary enclosure was ordered to determine if any further change would be required before the order was completed. This work was done under Air Force sponsorship relative to the development of precision navigational systems.

Dimensional Requirements—Ability of the technician to reach all areas of the work surface deserves careful consideration. Reference to standard dimensions for the typical U.S. male and female will prove an aid in determining the height of the enclosure, location of work openings, etc.

The work area within the enclosure should be large enough to accommodate a possible dozen assembly components. In addition, work space is also important outside the actual enclosure.

We eased handling by removing the microscope and the operator's head from the interior of the cabinet. He works through an almost horizontal glass surface directly above the work area.

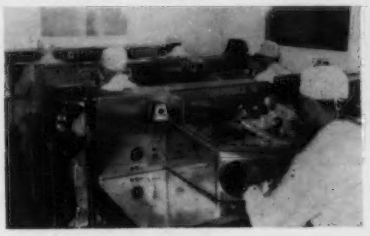
Fabrication and Structural Material—In making an enclosure that demands freedom from foreign matter, welds should be carefully ground and polished to eliminate particle - trapping crevices. Coved corners are necessary for the removal of matter trapped in the enclosure.

A noncorroding material, such as stainless steel, is probably one of the best materials available for many enclosures. Absence of a coating caused by corrosion on the inside of the enclosure precludes one source of unwanted particles. In addition, lack of surface finish eliminates the possibility of paint particles ending up in the assembly.

Air Flow—Although there is no set standard for blower capacity, we have found that an air flow of 20-40 cfm will provide adequate positive pressure in an enclosure occupying from 3 to 5 cubic feet. Access to the work area is best served by arm ports. Observation of the air-flow pattern through the use of dry ice and water will indicate possible turbulence in this critical area.

Utility Section and Filtering System—Division of the enclosure into two separate sections is desirable. The rear section contains the blower, filter, and other utilities. This gives more space and cleanliness in the actual work area. The use of access panels facilitates changing filters and maintenance of other utilities. In addition, incorporation of removable plates on the ends of enclosures allows two or more of the units to be combined if coupling between enclosures is desired.

Enclosure Adaptability — The assembly area within the enclosure should be designed for adaptability to various sizes of components and assemblies. Adjustable wells allow this versatility. A mechanical jack elevates or lowers an aluminum disc that serves as the work face.



Industry Notes

High altitude targets will be designed, developed and tested by Aeronca Manufacturing Corp. Six units slated to be tested within the next year at altitudes up to 250,000 ft.

Water supply for man on space trip is now being studied at General Electric's Space Sciences Laboratory under NASA contract.

Solid rocket fuel research at Minnesota Mining & Manufacturing is being pushed under renewed ARPA contract.

Production Techniques

First transfer machine built to specifications of the new Production Machine Tool Standards is being constructed by Buhr Machine Tool Co.

Process for hard-coating aluminum parts has been announced by Toro Manufacturing Corp.

New Facilities

Ryan Aeronautical plans a new high-energy forming production facility near San Diego.

Purdue University this month opens its new School of Aeronautical and Engineering Sciences.

U. S. Steel has opened new electromechanical laboratories at its Monroeville, Pa., research center. Control system research will include processes for missiles and space vehicle materials.

Jet Propulsion Laboratory of Cal Tech now has a new Propulsion Div. JPL is beginning a three year relocation and modernization of its solid and liquid propellant test cells near Pasadena, and is establishing new laboratories for studying solid and liquid propellant chemistry.

Air Products Inc. is building Test Cell "C" at Jackass Flats, Nev., for static tests of an advanced KIWI-A nuclear reactor on Liquid Hydrogen. This will bring the Project Rover nuclear rocket a step closer to flight test.

Amcel Propulsion Inc., subsidiary of Celanese Corp. of America, is now occupying a new research laboratory in Asheville, N. C., for R & D on propellants and explosives.

Callery Chemical Co. is completing modification of its Muskogee, Okla., high energy fuel plant. Pentaborane production begins shortly.

Union Carbide Corp. will build an Advanced Material Laboratory at Lawrenceburg, Tenn., for research and development on manufacture of improved graphite. National Carbon Co., Div. of UC, will conduct the research.

Business Moves

Temco Aircraft Corp. and Ling-Altec Electronics plan to merge into Ling-Temco Electronics Inc.

Bristol Siddeley and Piaggio & C. of Genoa have signed a license agreement for manufacture and sale in Italy of the Viper 11 turbojet.

Thompson Ramo Wooldridge's Tapco Group announce formation of its Tapco et Div.

NEW BALANCING FACTS

Be sure to get copies of these two important new bulletins on Tinius Olsen balancing machines—including detailed information on the causes and correction of unbalance, and other fileable technical data.

Write today for your copies of Bulletin 60 and "Tinius Talks about Olsen-Rava Balancing Machines."

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Yet the metal parts are thoroughly cleaned, burrs removed, in shortest possible time.

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Geodetic Satellites

Satellites planned for precise intercontinental mapping combine solar-powered flashing lights with a radio tracking system. Researchers believe these will allow surveying accuracies to within 80 ft.

This advanced surveying system will succeed preliminary work with Transit IB this winter and a "test-bed" optical satellite in late 1961. It will probably utilize both North-South and East-West orbits.

Researchers see development along these lines:

- Two sets of lights, one red and one blue. These would flash about once per second, utilizing solar-powered batteries boosted by solar cells. Working system is regarded as within present state of the art.
- New ground-based optical systems. These will probably utilize a flat glass photographic plate for maximum precision of measurement. Scientists are aiming for accuracy of about .3 sec of arc. Present systems give ± 2 sec of arc. The government will need new, highly accurate telescopes.
- Satellite to be boosted to between 1000 and 2000 miles. Satellites would reportedly weigh only a few hundred pounds.

At least one of the satellites would be in such an orbit that simultaneous sightings could be made on it from the U. S. and Europe.

Flashes will then be photographed against a stellar background.

Both red and blue lights will probably be used in order to determine directly the amount of differential refraction for colors. Precise photography, too, dictates two colors. The star background has a variety of colors, and the red and blue lights would cover this spectrum. The version slated for next year may, however, have only a blue light.

Radio systems to operate with the optical system, will reportedly utilize ground signal which is repeated by satellite instrumentation. These radio sightings will probably be simultaneous in final system. System to be tested in Transit IB will not have simultaneous sighting; it will use "Secor" tracking system, soon to be built.

Geodetic satellites are expected to give accuracy to within four parts in a million in measuring points 4000 miles apart. They will help locate the Earth's center-of-gravity and give more data on mass distribution in the earth.

The Army Engineer Research and Development Laboratories, Fort Belvoir, has charge of the geodetic satellite mission.

$4 Million Brain

SPACE SCIENTISTS at Marshall Space Flight Center, Huntsville, Alabama, examine console of a new, giant data processing system that will speed development of the Saturn space vehicle. Made by IBM the computer is called the 7090 (Seven Oh Ninety). It will be used as a standard design tool, and for "flying" Saturn payloads on simulated Moon trajectories. Flight of 9 days, 22 hr, and 45 min is sped through the machine in 3 min. Marshall will lease at $65,000/month, based on 176 hr work month. IBM engineer said cost of development would be absorbed in about 5 years. Second data processing system will be delivered to Huntsville this month. Left to right are: Dr. H. Hoelzer, director computation division, C. L. Bradshaw, deputy computation director, and Dr. R. Hoelker, deputy director aeroballistics.

Hovercraft Funding

London papers report that 2.7 million dollars are to be spent by the government backed Hovercraft Development Co. This money will be for three new types of hovercraft of which the first operational version is expected to appear in some 18 months.

One vehicle will weigh about 5 tons and be used for experimental purposes. The second will be a small ferry capable of lifting some 20 tons. The third will be a larger and most suited for overland operation.

index to advertisers

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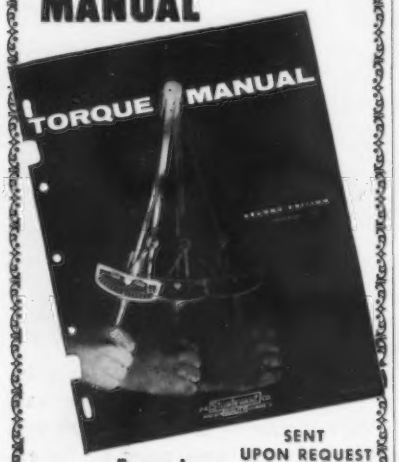
"TORQUE WRENCH" MANUAL



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Coming in the August issue of

AIRCRAFT & MISSILES

★ ★ ★

GROUND SUPPORT and GROUND HANDLING

A sizeable chunk of aircraft and missile funding goes into equipment needed for preflight and guidance of missiles and readying aircraft to leave the runway. Design and manufacturing aspects of this equipment will be discussed.

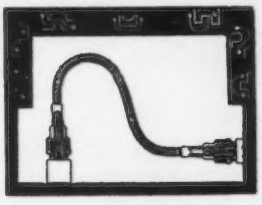
★ ★ ★

WESCON SPECIAL COVERAGE

A review of new aerospace electronics to be introduced at WESCON Show. A veritable guide to help aerospace buyers find the new products of interest to them at the show. Visit us at our booth #2717.

FLEXIBLE SHAFTS

Handle wide variety of control applications.



The Flexible Shaft today, although not complicated, is a specific component designed for specific applications. Industry in many fields, i.e., automotive, automation, aircraft, electronics, radio and television, machinery, and marine (to name but a few) have found flexible shafting to be more economical and yet more productive than whatever means they were employing to control motion from one unit to another where obstacles in the path of installation were impossible to do away with.

There are two types of flexible shafts. One is the mono-directional drive which utilizes a cable wound to rotate in one direction only. The outer layer of wire of the cable determines the direction rotation, and is wound so that the slack is taken up when the shaft is in operation, making it practically impossible for the cable to spring from its original shape. The other type is the bi-directional flexible shaft in which the cable is wound so that the slack is taken up no matter which direction the shaft is turned. The bi-directional shaft provides for both rotation and reciprocation, such as the opening and closing of a valve. • • • For complete information as to how flexible shafting may help you solve your specific control problem, write F. W. Stewart Corporation, 4311-13 Ravenswood Ave., Chicago 13, Illinois.

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YOUR NAME .....**TITLE** .....

COMPANY .....

PLANT ADDRESS .....

CITY .....**ZONE**.....**STATE**.....

Please check in A & B below which best describes:

A. Your Job Function

....1. Management
....2. Design & Engineering
....3. Production
....4. Procurement

B. Type of Plant or Facility

....1. Airframe
....2. Propulsion
....3. Electronic Systems & Parts
....4. Mechanical Systems & Parts
....5. Raw & Processed Material
....6. Engineering & Research Services
....7. Military & Government Facilities
....8. Parts & Supplies
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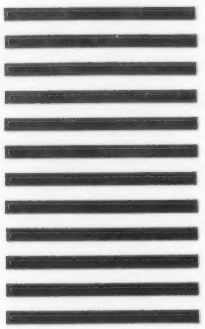

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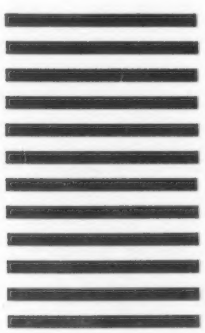

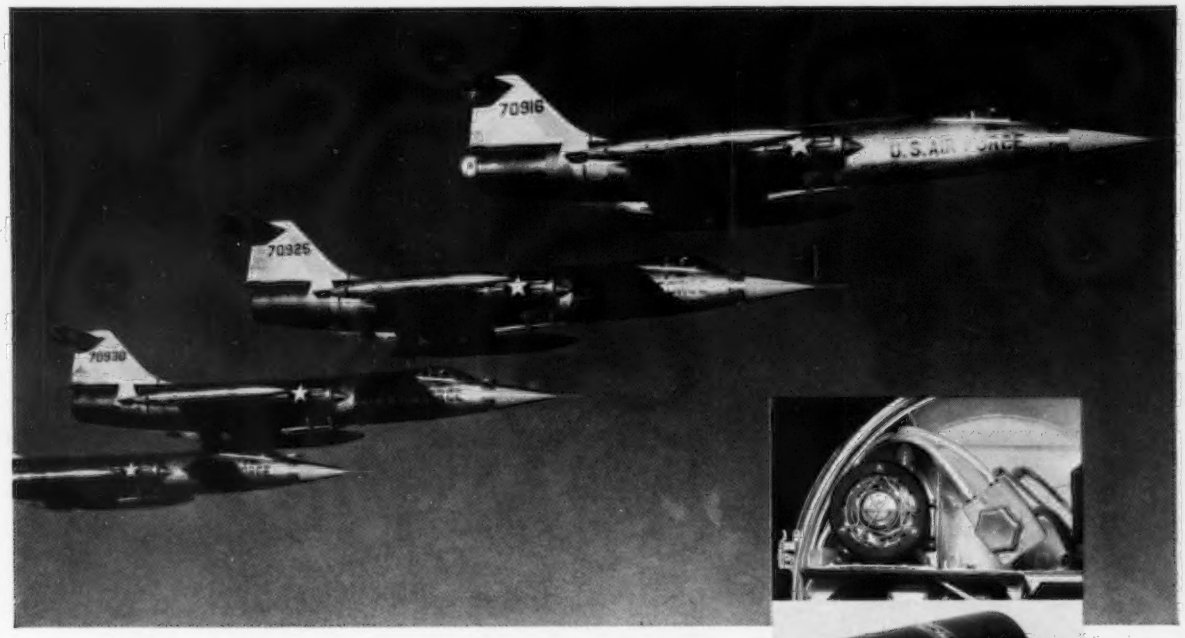

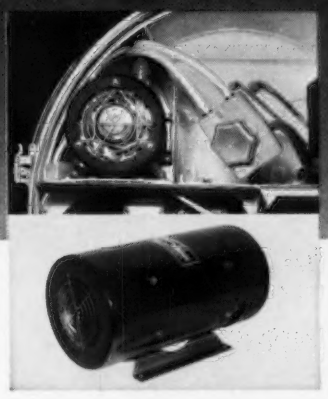

Tucked neatly into the nose of the Lockheed QF-104 is the Chatham Y-Series silicon transformer-rectifier, 28VS200Y, delivering 200 amps, 28 volts d.c. A second unit is positioned on the starboard side in the electrical load center of the airplane. These units are normally operated in parallel but each is capable of supplying the entire d.c. load upon which the QF-104 depends to carry out its mission.

Chatham Y-Series Transformer-Rectifiers Assigned Key Role in LOCKHEED QF-104

Lockheed's QF-104 adds double-barrelled potency to our air defense arsenal. An advanced version of the 1500 mph missile-carrying F-104—holder of the world's altitude mark (103,395.5 feet) plus eight time-to-climb records—the QF-104 can streak away on its space-age missions with dual effectiveness: either as a piloted aircraft or a remote-controlled drone.

According to Lockheed, the availability of d.c. power is an essential factor in assuring satisfactory mission performance of the QF-104. To furnish this vital power, Lockheed selected Chatham's dynamically new 200 ampere Y-Series silicon transformer-rectifiers.

There were many important reasons for this choice. Lockheed demanded the utmost in high-level flight performance and reliability, while restricting space and weight requirements to an absolute minimum. The Chatham Y-Series T-R's delivered.

Unsurpassed for proven reliability, the Chatham Y-Series transformer-rectifiers are available in a complete range of outputs—from 20 amps to 200 amps. Volume for volume and size for size these new "Y" units are smaller and lighter than any competitive equipment with similar capabilities. For instance, this 200 amp QF-104 unit weighs under 17 pounds and occupies less than 310 cubic inches.

Satisfying rigid specifications and critical performance levels for missiles, jet aircraft and commercial airliners is second nature to Chatham. That's because Chatham maintains complete control of every step in the production of power conversion equipment. For example, by producing its own solid-state elements—whether silicon, germanium or selenium—Chatham designers are not limited by the "specs" of commercially available components. By strictly controlling component dimensions and reliability, Chatham keeps size and weight to a minimum, while satisfying precise electrical specifications.

Send for Chatham brochure T-26 which shows many existing transformer-rectifier units. Or, outline your needs and Chatham will recommend an original design to do the best job for you. Chatham Electronics, division of Tung-Sol Electric Inc., Livingston, N.J. TWX:NK193.

CHATHAM . . . *world's leading supplier of airborne power conversion equipment.*

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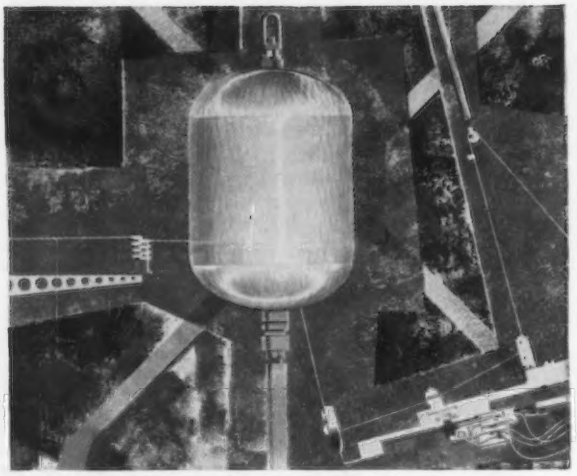
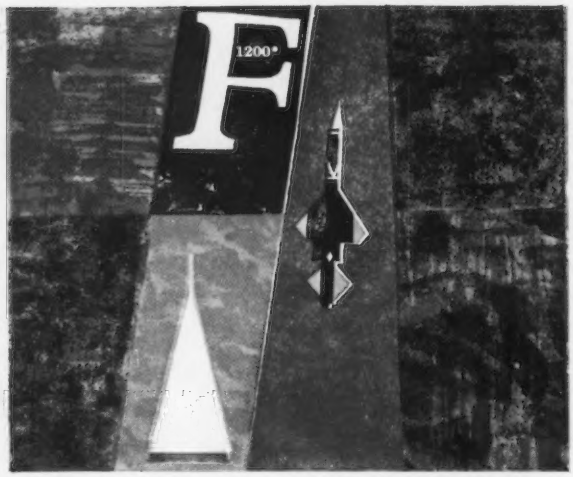
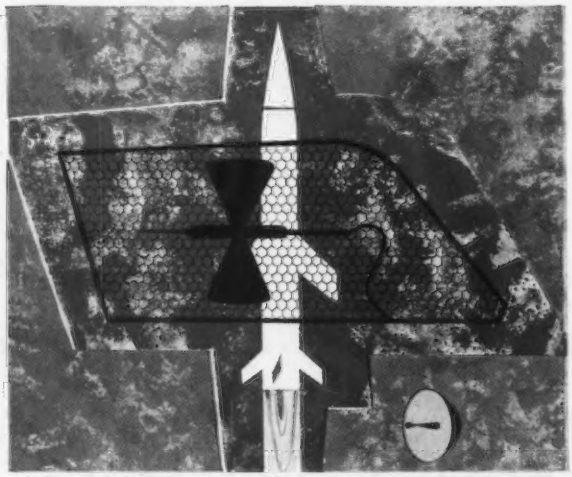


ROCKET MOTOR CASE. Brunswick's exclusive bi-axial Strickland "B" Process of fiber glass filament winding gives S-D ratio to 2,000,000, provides up to 7,500,000 psi modulus. By laying down filaments under tension, SBP excels in making cylindrical shapes, unusual contours, large range of sizes. Pre-stressing gives exactly controlled uniformity.



RADOMES. Brunswick's non-metallic materials boost heat tolerance of radomes and nose cones to 1000-1200°F for limited exposures. SBP filament winding gives highest-ever strength-to-weight ratios with significant weight savings over usual structures. With unmatched electrical uniformity, Brunswick builds to tightest tolerance for dialectric constants and compound configurations.

HONEYCOMB ASSEMBLIES now developed by Brunswick can support two million times their own weight. Brunswick research has created honeycomb assemblies of paper, fiber glass, aluminum and various combinations of these materials. Using the most advanced adhesive systems, these assemblies can be formed in compound curvatures with extremely close tolerances.



INTEGRATED ANTENNAS. Brunswick totally integrates all communications, telemetry and navigational antennas and reflectors within primary structures. No sending or receiving interference. All-plastic aircraft and missile assemblies give high weight-strength ratio, while providing aerodynamically clean lines. Can Brunswick Corporation help you in any way? Write or call today!

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